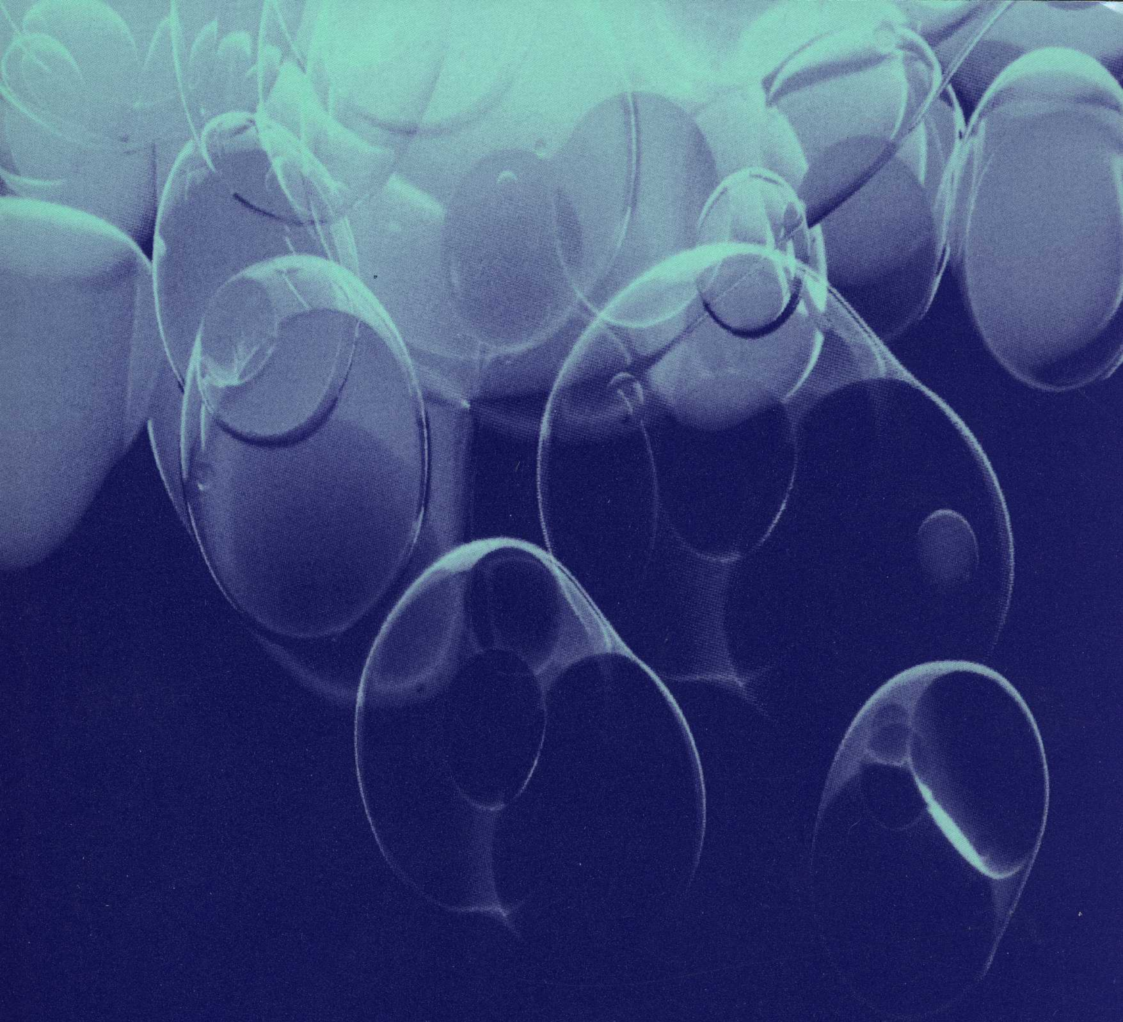

Spatial Representation

PROBLEMS IN PHILOSOPHY AND PSYCHOLOGY

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3
The role of physical objects in spatial thinking

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1 Physical objects and the connectedness of a space

In *Individuals*, Strawson held that the re-identification of places depends upon the re-identification of things. We re-identify places by their relations to things; we see that we are once again in front of the blackboard, for example. There is also a dependence of the re-identification of things upon the re-identification of places. But this mutual dependence is only a reflection of the fundamental character of reference to things and places in our thinking (Strawson, 1959, pp. 36–8). In consequence of the dependence of the re-identification of places upon the re-identification of things, Strawson said, 'the fact that material bodies are the basic particulars in our scheme can be deduced from the fact that our scheme is of a certain kind, viz. the scheme of a unified spatio-temporal system of one temporal and three spatial dimensions' (Strawson, 1959, p. 62; cf. Wiggins, 1963 and Woods, 1963).

It can hardly be denied that our reference to places is densely interwoven with reference to things, and that reference to things greatly enriches the capacity we have for reference to places. But that does not mean that reference to things is essential for reference to places. Indeed, the very notion of a 'thing' invites scepticism. Suppose, for example, that a creature re-identifies a place by using the shell of a room, or the structure of a maze. Is it then re-identifying the place by reference to things? It is often said that there is a level of language-use that is more primitive than the ability to refer to physical things.[1] This 'feature-placing' level of discourse can be given a preliminary characterization in terms of the distinction between mass terms and count nouns. We can distinguish between mass terms such as 'pandemonium', which do not admit the question 'How many?', and count nouns, such as 'tiger', which do. But there may be a use of 'tiger' as a mass term which is prior to its use as a count noun. This use of 'Tiger!' would be merely a response to the presence of tigerhood, by someone who might be quite incapable of making the distinction between one tiger and two being present, or having the idea of its being the same tiger again as was here previously.[2] We can distinguish between 'Mud!' at one place and 'Mud!' at another, without making any appeal to physical things. Since features do not typically spread all over all places in an environment, we can sometimes uniquely identify a place in the environment as 'the place which is F', for example. So we can use located features to re-identify places, given a certain stability in the layout of features in the environment. Yet it must certainly be true that there is some crucial role for physical objects in our ordinary spatial thinking. I want first to elaborate upon the point that place-re-identification does not depend upon physical objects, and then try to find what role they do play. We shall see that their distinctive role is to be found not in the re-identification of places, but in establishing the connectedness of a space: the fact that every place in a particular environment is spatially related to every other place in the environment.

We can begin with an extremely elegant and simple experimental paradigm used with infants by the developmental psychologist Linda Acredolo, to find whether and in what way they are identifying places (Acredolo, 1990). Her experimental space is an enclosure ten feet square, with two identical windows across from each other. There is a round table in the centre of the room, with a buzzer under it, and a long, movable rod attached. At the end of the rod is a seat on wheels, which can be rotated around the table. On top of the seat is an infant. In the training phase, the buzzer sounds in the centre. About five seconds later, an adult appears at one of the windows, calling the child's name and generally entertaining it for five seconds or so. Of course the child turns to look; and the pairings of buzzer and event, always at the same window, continue until the child has developed an expectation that the event will follow the buzzer; that is, on hearing the buzzer, the child turns towards the window before the adult appears. The chair was rotated around the table to the other side of the room after the training phase was over. The buzzer was sounded, and the experimenters watched to see towards which window the child looked in expectation of the event. Obviously, if the child has merely learnt a spatial response, such as 'look to the left' it will look towards the wrong window. There certainly are spatial behaviours which are more primitive than the ability to identify places – for instance, the ability to reach to the left or the right, or to jump out of the way of an oncoming object. Even if the infant has only a particular response, such as looking to the left, its behaviour may still be properly described as spatial. It may vary the type of muscular movement in many different ways, depending on the starting orientation of its head and body when the buzzer is sounded, so as always to achieve the result of looking to the left. So it may be impossible to describe the response as a non-spatial muscular movement. It might indeed be said that in the case in which the child is only giving spatial responses, it is using a notion of 'place': one in which no sense can be assigned to the idea that it is itself in motion, or capable of movement – it has an array of places, such as 'just within reach and to the right', which it carries with it through the world. Using this frame, something would be said to be in 'the same place' at one moment as at another moment, if at both times it was just within the subject's reach, and to the right, whether or not the subject had, as an observer using a more standard frame of reference, such as the walls of the room, might say, 'moved' in the meantime. We can certainly imagine a subject for whom this way of thinking is a possibility. For example, an oriental despot might so arrange matters that however and whenever he moves, there is always Turkish delight just within reach and to the right. At this very primitive level, there would evidently be no dependence of place-re-identification upon thought of physical objects.

We have also to consider the case in which the child manages to use the information available to it through the rotation to keep track of the right window, and look towards it, even though this means giving a different spatial response, such as looking to the right rather than looking to the left. Acredolo found a gradual transition from giving dominant weight to spatial responses, to giving dominant weight to this kind of place learning as the infants grew older; or more precisely, as the time in which the child had been capable of self-locomotion increased. When we reflect on just how the child which operates not as a despot, but using a more standard criterion of identity, manages to re-identify places, it is hard to believe that it must be doing so by recognizing physical things. Perhaps it simply keeps its eye on the place as it is moved around. And there are many more sophisticated ways in which, without using physical objects, the child who succeeds in the Acredolo paradigm might re-identify the place, otherwise than by simply keeping an eye on it. For example, it might do it by keeping track of its own movements as it is rotated. If this is what is happening, then it does not depend upon any ability to think in terms of physical objects. It is also evident that the whole class of animals which manage to find their way back home simply by keeping track of their own movements – the directions and distances of their travel from moment to moment – then using path integration to find the direct route home – are re-identifying places (see for example Müller and Wehner, 1988). In response to that point, it might be acknowledged that this kind of re-identification of places does not depend on reference to physical things, for here thought about places does not depend on the use of landmarks. But, it might be said, there plainly are instances in which landmarks are used to reidentify places over time. And in such cases, the landmarks used must be enduring things. For a landmark to function as a landmark, it must stay in the same place, or be at the same place, over a period of time. It must be a constant feature of the place. And, this line of thought continues, an object just is a spatio-temporally continuous feature, or group of features. So the enduring character of the places requires the enduring character of the things.

At this point we have to scrutinize the notion of a material body, and the contrast between material bodies and features. The contrast I want to pursue is not simply one between possession and lack of criteria of identity. It has to do rather with the type of criterion of identity that physical objects have. I do not want here to try to give a full analysis of the notion. I want, rather, to highlight one difference between thinking in terms of features and thinking in terms of objects. In contrast to features, the condition of a thing at any one time is thought of as being causally dependent upon its condition at earlier times. One of the determinants of its properties at a given time is which properties it had earlier, and this is so no matter how much it has moved around. It might, indeed, be held that internal causal connectedness is more basic than spatio-temporal continuity, in our notion of objecthood (cf. Shoemaker, 1984; Slote, 1979). Once we acknowledge this causal dimension of the ordinary notion of an object, we can find room for the possibility of landmarks being used which are not objects. We can certainly make sense of someone finding their way around using stably located features, or groups of features, which they do not think of as having that internal causal connectedness over time. Someone might think in a way that was more primitive than any that involved thought of internal causal connectedness, and *a fortiori*, more primitive than any that involved thought of physical objects. They could still be re-identifying places.

Having put the point in this way, though, it might be wondered whether we ever think about physical objects at all; for surely this notion of 'internal causal connectedness' is more abstract than anything we ordinarily use. But the abstractness is simply a product of the generality of the description of an ordinary mode of thought. The notion of 'internal causal connectedness' is presupposed in our grasp of the way in which objects interact. For if we are to have any appreciation at all of the effect that one object can have upon another, in a collision, for example, we have to understand that one central determinant of the way the thing is after the collision will be the way that very thing was before the collision. We have to understand the dependence of objects on their earlier selves, to grasp that their earlier selves are only partial determinants of the way they are now, and that external factors may have played a role. We need a distinction, then, in describing our ordinary thought, between the causality that is, as it were, internal to an object, and has to do with its inherent tendency to keep its current properties, or for them to change in regular ways, and the causality that has to do with the relations between objects, and the ways in which they act upon each other (Shoemaker, 1984, p. 241). We can, then, say a little more about what it means to be using stable features as landmarks, rather than enduring things. Someone who is not operating with the conception of physical things is someone who does not have the conception of 'intrinsic causality'; the way in which the later stages of a thing are causally dependent upon its earlier stages. This person does not have the conception of the earlier stages of the thing as a partial determinant of the upshot of any causal interaction between it and something else. So this person cannot have the conception of 'causal interaction' at all – there really is no saying what would happen if we were somehow to engineer a collision between two of these groups of features. To try to give an answer, one would have to appeal to the 'causal inertia' of the group of features, and that just is an appeal to their intrinsic causality, which is importing the notion of a physical object which has those features.

One might try to provide criteria of identity for located features, but this will simply serve to emphasize the distinction between features and physical things. For instance, one might say that at any given time, two located features are identical just if they occupy the same place. And we might try to allow for the possibility of movement by a feature. For we surely do want to be able to acknowledge that there may be a given qualitative feature at each of a continuous series of neighbouring places over a given time; and it seems hard to resist the description of that as a case in which a single particular feature is continuously changing its position. If we talk in this way, then we have to acknowledge that the total spatial career of a particular feature, over a period of time, is essential to it; if we assume that it had some quite different spatial career, then we simply lose our grip on it being that very feature that we are thinking about. In contrast, we can make sense of a particular object's having had a quite different spatial career, partly because of the extra structure in our conception of the object afforded by our grasp of its internal causality. That is, we can, for example, hold constant the origin of the thing, even though we vary the route that it takes.[3] This is not possible in the case of something we are thinking of simply as a feature. Just because we are not appealing to the idea of its internal causal relatedness, we have no way of making sense of the idea of the origin of a particular feature. So there is nothing we can hold constant, as what identifies it as that particular feature, while varying its route. The spatial career of a located feature is essential to it; in contrast, the location of an object at a time is the paradigm of a contingent fact.

Once we have explained the distinction between features and material objects in this way, it is hard to see why the reidentification of places could not use distinctive features rather than physical objects. Certainly this seems to be the right way to describe the reasoning of many animals. Homing pigeons, for example, are certainly capable of reidentifying places. But supposing them to be capable of reidentifying places by using some features which are distinctive of them, does not depend upon supposing the pigeons having any conception of the landmarks as objects with the internal causal connectedness characteristic of objects. The pigeons may have no expectations at all as to what would happen in the case of a collision between two landmarks.[4]

Success in the Acredolo paradigm shows how an infant might be able to re-identify one particular place over time. As we have seen, this does not seem to depend on reference to physical things. But success in the paradigm does nothing to display any capacity one might have to think of places as all spatially related to each other. It does not display the connectedness of the space. The paradigm simply tests for the re-identification of a single place over time. It does nothing to establish that the child has any conception of the place as one of a network of spatially related places; it does nothing to establish that the child is thinking in terms of a unified, or connected, space. The conception of a place as one among a network of spatially related places is at least as fundamental to our thought about places as the ability to re-identify places over time. Any appreciation of the connectedness of the space will have to involve the background method which the child uses to keep track of places over time. As we shall see, it is when we attend to the distinctions between various ways in which we can register the connectedness or unity of the space, that we find the role in our spatial thinking of the notion of a physical object. The thesis is still in play that if the child is to have a certain type of appreciation of the connectedness of the space it is in, it must be capable of referring to physical things. It would have to be made out that there is a conception of connectedness which depends upon the conception of physical things.

What does it take to grasp the spatial connectedness of a space? To answer this, we have to consider the relation between grasp of spatial and grasp of causal concepts. On one view, we need spatial concepts to elucidate the notion of cause (Salmon, 1984, ch. 5). But this view should not be pressed so hard as to imply that we can ascribe spatial representations to animals in a way that outruns their capacity to give causal significance to them. What makes spatial reasoning reasoning about one's environment, about the space one is in, rather than a purely formal exercise in mathematical computation, is the ability to grasp the physical significance of the spatial representations one forms. So we must look for an account of the laws or regularities, however probabilistic or open to exception, which connect spatial properties with other physical properties. To do so is not to demand definitions of spatial concepts in terms of other physical concepts. There is no presumption that the spatial concepts are less primitive than any others; there is no presumption that we can separate out, from the flux of physical thinking, some regularities which alone deserve to be elevated into definitions. There may be no definitions to be had (Friedman, 1983, pp. 264–339). Still, insofar as spatial reasoning is to be understood as reasoning about one's actual environment, rather than as pure geometry, it is theoretical. It is only its figuring in an 'intuitive physics' of one's environment, through regularities connecting the spatial properties with other physical properties, that makes it reasoning that is not purely mathematical, but rather, reasoning about the space in which one lives.

Notice also that we have to explain why an animal's capacity to engage in spatial reasoning might have been selected for under evolutionary pressure. And if the reasoning has no physical significance, then it has no selection value; it can be of no assistance to the animal in coping with its surroundings. We ought to be reluctant to ascribe spatial reasoning whose use by the organism defies explanation in terms of selection pressures. If we subscribe to an evolutionary–teleological view of content-ascription, we will not simply be reluctant to do this but regard it as incoherent to do so.[5] Of course, there are views on which spatial reasoning is simply a form of causal reasoning: spatial notions can in some sense be reduced to or explained in terms of causal notions (van Fraassen, 1985; Sklar, 1983). But we can accept the need to relate the ability of a creature to represent space to its capacity to give physical significance to those spatial representations, without insisting on any such reductionist thesis.

If we ask how one could exercise grasp of the fact that every place in one's environment is spatially related to every other place in it, the answer is that we have to look at the physical significance one assigns to this relatedness; at the way one grasps the causal connectedness of the space. Because of their internal causal connectedness, physical things have a special role in registering the connectedness of space. Specifically, reference to physical objects is used to grasp the connectedness of the space through spatial thinking at a certain 'absolute' or 'objective' level; for their internal causal connectedness precisely means that the possibility of their travel through space can give physical significance to its spatial connectedness. Features could not do this work, because of their lack of internal causal connectedness, and the impossibility of their having routes other than the routes that they actually take; the possible 'trajectories' of actual features could not capture the full modal force of the connectedness of the space. To delineate the exact role that physical objects play, though, we have first to remark that there are many ways in which the conception of the space as connected could be grasped which do not depend on physical objects. At first, this may seem quite impossible. As I have described it, thought at the level of feature-placing is, as it were, causally inert. So how could a creature reasoning at this level possibly register the physical significance of anything, let alone the connectedness of a space?

Within psychology, the question of the connectedness of a creature's conception of the space it is in has become familiar in the context of discussion of whether one or another animal has and uses cognitive maps. For example, consider an instructive recent dispute over whether honey bees use maps – 'instructive' because it puts pressure on the notion of a 'map'. In effect, the protagonists agree in defining 'map' in terms of the kinds of connectedness represented among the places represented. Thus Wehner and Menzel write:

> Even though the term *cognitive map* is often defined rather vaguely and applied to various kinds of animal orientation, we hope to be in line with most workers in the field – and especially with Tolman (1948), who coined the term – when we use it in the way a human navigator does. Seen in this light, a cognitive map is the mental analogue of a topographic map, i.e. an internal representation of the geometric relations among noticeable points in the animal's environment. In operational terms, this means that an animal using such a map must be able to compute the shortest distance between two charted points without ever having travelled along that route. More generally, it must be able to determine its position, say, relative to home, or to any other charted point, even when it has been displaced unexpectedly to an arbitrary place within its environment (Wehner and Menzel, 1990, pp. 403–4).[6]

The reference to metric properties ('shortest distance') here seems to make this definition insufficiently general: we need a definition which relates to the topology of the representation only, rather than any metric properties it might have; we should certainly want to allow that a map inscribed on rubber, or a city Metro map, or their psychological counterparts, are maps, even though they do not represent metric properties at all. But we could keep the focus on connectedness in the representation without appealing to metric properties, while still acknowledging that even an unmetricized map will allow some notion of 'optimum route' – Metro maps are not entirely useless. It is through its possession and use of such a map, metric or not, that an animal gives physical significance to whatever grasp it has of the connectedness of the space it is in: the fact that any place is spatially related to every other place. Once we put things in this way, though, it seems apparent that there will be many sophisticated navigational systems that need make no essential use of physical objects at all, rather than of features as landmarks. In section 3 I shall consider the distinctions that can be drawn among different navigational systems. Then, in section 4, I shall introduce a notion, 'causal indexicality', that characterizes all the ways of thinking about space described up to that point. In section 5 we shall see that physical objects may have a foundational role to play in the operation of a way of thinking about space that is not causally indexical.

2 Egocentric space

Before proceeding to the topic of maps and connectedness, there is a fundamental objection which has to be addressed here. The child in either phase of the Acredolo paradigm could be said to be identifying places egocentrically: it identifies them as 'to the right', 'in front and up a little' and so on. What is different between the child in the early stage and the child in the late stage is the criterion of identity that it uses for places over time. But in either phase, the place-identification that it uses in controlling which way the child looks is egocentric. And this suggests that the child is after all identifying the places around it by reference to a physical object, namely itself. We could put the point by asking how we are to distinguish the class of egocentric frames of reference – that is, egocentric methods of identifying the places in one's environment. On the face of it, an egocentric frame of reference is a body-centred frame of reference; or one which is centred on a part of the body. The developmental psychologists Herbert Pick and Jeffrey Lockman put the idea as follows. They define a 'frame of reference' to be 'a locus or set of loci with respect to which spatial position is defined'. 'Egocentric' frames of reference then are those which 'define spatial positions in relation to loci on the body'. They are contrasted with 'allocentric' frames of reference, 'which simply means that the positions defining loci are external to the person in question' (Pick and Lockman, 1981, p. 40). This definition seems indeed to give a reductive account of the notion of an egocentric frame, defining it in terms of notions which genuinely seem to be more fundamental than it. If the definition is correct, then even the very simple place-identifications we have been considering, by the child in either phase of the Acredolo paradigm, depend upon reference to a thing, namely the body.

It is worth reflecting on the general form of the definition. In trying to say what is characteristic of an egocentric frame of reference we are not dealing with a problem in pure mathematics. It is not, for example, on a level with the question whether a frame of reference uses polar or Cartesian co-ordinates. Thinking in purely formal terms, the best we could do would be to say that it must be possible, using an egocentric frame, to specify spatial relations to a single privileged point; but that would not separate an egocentric frame from one centred on the sun, for example. We have to say something about the physical significance of the origin of the frame: we want to say, for example, that it must be centred on the subject. This notion of 'the subject' is not a purely formal notion of pure mathematics. But saying where the frame is centred is only one way of giving physical significance to the formal notions. An alternative would be to consider the physical significance of the axes of the frame of reference, and to take them as fundamental: an egocentric frame would then be one whose axes had a particular kind of physical significance. It would then be a substantive thesis, rather than a definition, that egocentric frames are invariably centred on the body, or a part of the body. And it would be quite wrong, on that approach, to suppose that in using an egocentric frame one must be identifying places by their relations to a body already identified.

The definition of an egocentric frame as a body-centred frame takes for granted the general notion of an object-centred frame of reference, and says that the egocentric frames are a particular class of object-centred frame, namely, those which are centred on the body or a part of the body. The general notion of an object-centred frame is certainly legitimate. Consider an object such as a table, or a bus. We can think of the internal spatial relations between its parts. We can use this system of internal spatial relations to identify points within the object. There may be natural axes that the object has. For example, given a pillar-box, we could define a set of axes by reference to its long axis, its 'line of sight' through the slot and its 'coronal plane', through which the door moves when it is opened. So far, what we have is a way of identifying points internal to the object. But the system of spatial relations that we have set up between the parts of the thing could be further used to identify points external to it. We could, for instance, identify a coconut on a palm tree as lying on a line through the bottom of one leg of the table, and the top of another, and a hundred yards distant in the direction going from bottom to top. This way of identifying places need not be used only with inanimate objects as its basis. One could equally well take the internal spatial relations between the parts of a horse, or its natural axes, and use them to give fully allocentric identifications of the places around it. One could do the same with a human body. One could do the same with what is in fact one's own body. And then, by Pick and Lockman's definition, what we have is an egocentric frame. But evidently, there is a finer distinction that we want to make here. For it is not as if we can assume extensionality: not just any way of thinking of the subject will do. The notion of egocentric space is a psychological notion; the reason why we want it is to explain why the infant, for example, turns one way rather than another. In particular, perceptual knowledge of the body will not do. Merely seeing one's own body in a mirror, for example, and using it to set up a system of axes, will not provide one with an egocentric frame.

The obvious proposal is that subjects have to be using the direct, non-observational knowledge of their own bodies constituted by their possession of a 'body-image'. In one use of the phrase, 'the body image', it has to be thought of as referring to a relatively long-term picture of one's own physical dimensions. So someone's body-image might be changed as a result of their having a skin graft, or the loss of a limb, or simply by growing up. In this use of the term, the 'body image' provides one with a general sense of what kinds of movement are possible for one. It assigns a particular structure to the creature, which underlies its possibilities of movement (O'Shaughnessy, 1980, p. 242). We cannot directly use that to set up a system of axes – it assigns no particular shape to the body. What we need, rather, is what O'Shaughnessy calls the 'here-and-now' body-image, which 'is given by the description or drawing or model one would assemble in order to say how the body seems to one *at a certain instant.* For example: torso straight, right cylindrical arm stretched out from body, crooked at right angles, etc.' (O'Shaughnessy, 1980, p. 241). Given its possession of such a body-image, it can plot the spatial relations between the various parts of its body, and use them to construct a body-centred set of axes which will indeed be the egocentric axes. This proposal relies on a direct relation between the subject's body-image, and its ability to act. We have to think of the body-image as giving the subject a practical grasp of the ways in which it is possible to act; the possibilities of movement open to it. Of course, there must be some relation between these two conceptions of the body-image (O'Shaughnessy, 1980, p. 247). The immediate problem is, though, to understand why this shift, from 'outer perception' of the body, such as seeing it in a mirror, to 'inner perception' as provided by the short-term body-image, should be thought to achieve anything. After all, as we saw, simply managing to use the spatial relations between the parts of the body to set up a system of axes does not in general secure one an egocentric frame. Why should we think that an egocentric frame is guaranteed if one relies on the spatial relations between the parts of the body given in 'inner perception'? The point here is that there is in general no direct connection between the mere use of an arbitrarily chosen body to set up co-ordinate axes, and the subject's capacity for directed spatial action. What the present proposal relies on is a direct relation between the subject's short-term body-image, and its ability to act. We have to think of the short-term body-image as giving the subject a practical grasp of the ways in which it is possible to act; the possibilities of movement open to it. The reason why this seems promising is that the short-term body-image has direct connections with action, of the type possessed by the egocentric axes. The proposal is that we can view the direct connection between action and egocentric space as a product of the direct connection between action and the short-term body-image. But now we have to ask how it can be that the body-image has this direct connection with action. And we immediately face a dilemma. For how are the spatial relations between the parts of the body given in the body-image? One possibility is that they are given in egocentric terms – that one foot is represented as to the right of another, below the rest of the body and so on. But then it can hardly be held that the subject uses the natural axes of its body to set up the egocentric axes; rather, it has already to use the egocentric frame to grasp the spatial relations between the parts of its body. Alternatively, suppose that the spatial relations between the parts of one's body are given in non-egocentric terms. Then there is no prospect of using the axes of one's body to set up an egocentric frame; one is in no better position to do this with respect to the body of which one has 'inner perception' than one would be with respect to a body of which one has 'outer perception'. In both cases the problem is the same. One's grasp of egocentric spatial axes, with their immediate connections to moving and acting, cannot be generated from a grasp of spatial relations which are given non-egocentrically. Grasp of egocentric spatial axes must be taken as primitive.

This means that a certain kind of reductive ambition for the definition of an egocentric frame as a body-centred frame has to be abandoned. We cannot view this definition as explaining the notion of egocentricity in more fundamental terms. We cannot see it as defining egocentricity in terms of (a) the generic notion of an object-centred frame of reference, plus (b) the notion of a body-centred frame. For when we inquire into the needed notion of body-centredness, it turns out that it already appeals to the notion of the body as given in the body-image, with its spatial relations given egocentrically. In particular, then, we cannot take the body-image to be more fundamental than the egocentric axes: we cannot derive them from it. The egocentric axes have to be taken as primitive, relative to the body-image.

It might be asked whether the body-image is not at any rate co-ordinate with the egocentric axes, so that they have to be taken to be equally fundamental in the direction of spatial action. But while some egocentric reference frame is evidently essential if we are to have spatial action – otherwise the action could not be regarded as spatial at all – it does not seem that a subject needs to have a body-image in order to be capable of egocentric spatial action – action we would want to explain by appealing to its possession of an egocentric frame of reference. The co-ordination and direction of spatial action may be achieved by purely distal specifications of the locations which are the endpoints of the actions, without the subject having a single central body-image at all (Scott Kelso, 1982). If a body-image is superimposed on the subject egocentric axes, that is additional to the requirements for it to be thinking about places egocentrically. So when the subject is identifying places egocentrically, it cannot be thought of as doing so by first identifying a physical thing – itself – through a body image, and then identifying places by their relation to its body. Rather, its capacity to use the egocentric axes is more fundamental than its capacity to think in terms of a body-image. The egocentric identification of places does not depend upon a prior identification of a body. The notion of the egocentric frame is more fundamental than the relevant notion of body-centredness. It is only when we have elucidated the notion of an egocentric frame that we are in a position to say what this notion of body-centredness is.

How then are we to characterize egocentric frames of reference? One alternative approach would be to say that an egocentric frame is one defined by the axes 'up', 'down', 'left', 'right', 'in front' and 'behind', with the origin identified as 'here'. Places cannot be identified by directions from a single origin alone. We should have to add something about the way distances are measured, using this frame of reference; or at least we need some kind of order relation. Even so, this approach would not give us enough to say in general what an egocentric frame is. We want to be able to allow as intelligible the hypothesis that humans may use many different egocentric frames. Consider, for example, the axes defining the movements of the hand in writing. There is no reason to suppose that this will be the very same set of axes as is used to define the movements of the whole body. Nevertheless, it is still an egocentric frame. So an approach which tries to define what it is for a frame to be egocentric by simply listing a particular set of axes will not work. Again, there is no reason to suppose that all species will use the same egocentric axes. For example, creatures which are differently jointed to us, or which live deep underwater, may use different axes. Finally, even if we could, by listing a suitable set of axes, give an extensionally correct identification of the egocentric frames, we would still have the explanatory work to do. We should still have to explain what it was about the terms 'left' and 'right', for example, that made them particularly connected to moving and acting, for instance. Even so, it may still be the case that the right way to give a general definition of the notion of an egocentric frame of reference is by defining a class of axes, rather than by making a general demand about where the frames must be centred. And, of course, we would expect that an extensional approach here would not succeed: we have to grasp how the subject is apprehending those axes.

The axes that are distinctive of an egocentric frame are those which are immediately used by the subject in the direction of action. They may include, but need not be confined to, the natural axes of the body. In the case of 'in front' and 'behind', we have a distinction defined in terms of the body and its modes of movement and perception. Its application to us depends on exploiting ways in which we are not symmetrical. If we were symmetrical, being double-jointed and able to look either way, then our current notions of 'in front' and 'behind' simply could not be applied to ourselves, could not guide our actions in the way that they do. But we are not symmetrical in this way, and the distinction does guide our actions. In the case of 'up' and 'down', it does not seem that we have here a distinction which is defined in terms of asymmetries of the body. It has to do rather with orientation in the gravitational field. The extensive apparatus we have to tell us how we are oriented in the gravitational field is precisely an apparatus to tell us which way is up. Of course, the reason this matters to us is the pervasive influence of gravity on every aspect of our ordinary actions. So here we have an egocentric axis which is not defined as a natural axis of the body. Of course, there is such a thing as the long axis of the body, but that is not the same thing as 'up' and 'down', which continue to be defined in terms of the gravitational field even if one is leaning at an angle. The case of 'right' and 'left' does not follow either of these models. The fundamental distinction here does not have anything especially to do with the bodily axes at all. It is not, as in the case of 'in front' and 'behind', that there is any bodily asymmetry that the distinction labels, since animals are generally right/left symmetric. Nor does it, like 'up' and 'down', label some external physical magnitude which is of general importance for action. None the less, it is evidently an axis which is used in the direction of action.

I said that egocentric axes are those which are 'immediately' used in the direction of action. It may be that no very precise definition can be given of that notion of 'immediate' use, and that the notion of an egocentric reference frame must to that extent remain a rough and intuitive one. But we can get some sense of the required conception by contrasting egocentric frames, such as used by the infant in the Acredolo paradigm, with more complex dead reckoning systems: that is, systems which enable one to keep track of where one is by keeping track of how fast one has been moving, in what direction and for how long. The point about such systems that matters here is their use of a compass which is external to anything used in the immediate direction of action. For example, an animal might use the position of the sun, together with its knowledge of the time of day, as a compass. It can use this to keep track of each of its various swoops and sallies, and so to plot the direct route home. But before it can actually translate this into action, it has to know the direct route home not merely in terms of direction specified in terms of the external compass: it has to know which way to point itself to travel in that direction. It is in this sense that the egocentric axes are 'immediately' used in the direction of action, whereas the external compass is not. Of course, a dead reckoning system could also use the egocentric axes themselves, though in practice this would mean a considerable loss in accuracy. Notice, incidentally, that these dead reckoning systems are body-centred; what makes them not egocentric is the axes that they use, and the indirectness of their role in guiding action.

It thus appears that the re-identifications of places achieved by children in the Acredolo paradigm can be managed without any reference being made to physical things. But all that we have so far is that ability to home back in on a single place, to re-identify it. We do not yet have any ability to grasp the physical significance of the connectedness of the space: the fact that every place in the space is connected to every other. As I said, it is here that we find the role of physical objects in spatial thinking. As we saw, though, it must also be acknowledged that one way in which the connectedness of a space can be grasped is through possession and use of a cognitive map; and there is, on the face of it, no reason why that should require the conception of an object. But how can the causal significance of the connectedness of a space be grasped by a creature which is thinking only in terms of causally inert features?

3 What is a map?

In the literature on cognitive maps, a distinction is sometimes drawn between 'absolute' and 'relative' modes of spatial thinking. The notion of 'absolute' space that is being used here has to do with the distinction between ways of thinking that involve an explicit or implicit dependence upon an observer or agent; and those which have no such dependence. These latter are the 'absolute' modes of spatial thought. It has often been maintained that this notion of an 'absolute' spatial conception is at best a kind of limit case, derived from increasing attenuation in the dependence on the observer or agent. The idea that one might actually attain this limit is regarded as subject to empiricist or pragmatist critique. Thus Poincaré wrote: 'Absolute space is nonsense, and it is necessary for us to begin by referring space to a system of axes invariably bound to our body' (Poincaré, 1946, p. 257, cf. 244–7). More recently, though, in work in the tradition begun by Tolman, this idea has been challenged, most powerfully by John O'Keefe and Lynn Nadel:

> Most authors attempt to derive all psychological notions of space from an organism's interaction with objects and their relations. The notion of an absolute spatial framework, if it exists at all, is held by these authors to derive from prior concepts of relative space, built up in the course of an organism's interaction with objects or with sensations correlated with objects.
>
> In contrast to this view, we think that the concept of absolute space is primary and that its elaboration does not depend upon prior notions of relative space. . . [there] are spaces centred on the eye, the head, and the body, all of which can be subsumed under the heading of *egocentric space*. In addition, there exists at least one neural system which provides the basis for an integrated model of the environment. This system underlies the notion of absolute, unitary space, which is a non-centred stationary framework through which the organism and its egocentric spaces move (O'Keefe and Nadel, 1978, pp. 1–2).

The point of the empiricist or pragmatist critique is to insist that this 'absolute' conception cannot legitimately be ascribed to an organism; we cannot make any sense of any such conception. Now we cannot resolve this issue simply by pointing out that animals have navigational skills. For there are many types of navigational system which do not have this 'absolute' character. We shall shortly consider two such systems. What we would like is to see a detailed account of what an 'absolute' mode of spatial thinking would look like, together with some account of how it could be that a creature could be said to grasp such a mode of thought. In some recent papers, John O'Keefe has set out a model which is held to be of precisely this 'absolute' or 'allocentric' character (O'Keefe, 1990; 1991). As we shall see, the crucial feature of this model is the way in which it captures the connectedness, or unity, of the space mapped; that is, the spatial relations that any one place bears to any other place.

On this model, the animal has to find what O'Keefe calls the 'slope' (or 'eccentricity') and the 'centroid' of the environment. Finding the slope is a way of using the distribution of cues in the animal's environment to provide it with compass directions. That is, it defines a direction for the environment, which does not depend on which way the animal itself is pointing. Or, to put it another way, as the animal is rotated, its angle with the slope of the environment changes, so that it can use its angle with the slope as a way of defining which way it is pointing. On the other hand, if the animal is moved from one place to another, without any change in which way it is pointing, its angle with the slope remains constant. The centroid of the environment is 'the geometric centre or centre of mass of the cues in the environment' (O'Keefe, 1990, p. 306; 1991, p. 283). It can be thought of as a point which has the following characteristic. If each cue in the environment is assigned a mass of one unit, and rigid rods used to connect the centroid to each cue, then the resulting construction will balance evenly around the centroid.

The details of how the slope and centroid are computed are not crucial to the present discussion, but I include them for the enthusiastic reader. We begin with the animal's ability to keep track of its own displacements, and its perceptual knowledge of the vectors from it to each of a number of landmarks in its environment. These vectors specify directions in terms of the axes of the animal's own body. The problem then is to use these egocentric vectors to generate a non-egocentric representation of the places around it. On this model, the animal has now to calculate the slope and the centroid of the environment. The slope is defined as 'the deviation from symmetry or isotropism of the cue configuration in different directions.' Suppose we have a pair of landmarks, with their egocentric positions given – so their direction and distance from the subject is given. The line connecting them has a particular gradient in egocentric space. We can take the gradients of all the lines connecting each pair of cues in the environment. We can then take the average of all these individual gradients; that gives us the slope of the environment. The way in which this slope is identified in the animal's egocentric space will of course vary depending on what direction it is facing in; so rotations of the animal will change the measure of the slope. But the slope is invariant with translations of the animal which change its position without changing the direction in which it is pointing. This means that the slope can be used as a non-egocentric measure of direction. The centroid is defined as 'the geometric centre or centre of mass of the cues in the environment.' One way to find the position of this place is by taking the average of all the egocentric vectors to the landmarks around the subject.

Now, once the slope and the centroid for a particular environment have been established, we can use them to define positions in it. We can define a position by giving the vector to it from the centroid: that is, its distance from the centroid, and its direction from the centroid, given as the angle of the straight line connecting it to the centroid, with the slope. So the animal can use this to store and remember the location of a particular target: the vector to it from the centroid. It can also find out where it is itself, by finding the current vector from it to the centroid. One type of activity that the model can be used for is to enable the animal to predict its next location on the basis of its current location and movement. The animal's displacement can be represented by a vector giving distance and angle with the slope; this, together with its knowledge of its original position – that is, the vector from its original position to the centroid – means that it can keep track of where it is even if landmarks are removed (O'Keefe, 1990, p. 307; 1991, pp. 286–90). Also, the system can be used to find the movement needed for the animal to get from where it is to a target location. Given two vectors, one representing its current location – the vector from it to the centroid – and the other the vector from the centroid to its target, the system can subtract the two and calculate the movement vector required to get directly to the target (O'Keefe, 1990, p. 308; 1991, p. 290). The computational power of the system enables the animal to give physical significance to the connectedness of the space, in quite a strong sense: no matter where the animal is, it can represent the vector from itself to any other location. But although it can represent the connectedness of the space in this strong sense, there is no evident dependence of the system on physical objects being used as cues. For all that we have so far, the cues might well be located features. The crucial issue, as we shall see, has to do with the sense in which the connectedness of the space is represented. There is a sense in which the animal using this system does not have a fully 'disengaged' or 'objective' grasp of the connectedness of the system; and it is that strong notion of connectedness that defines the intuitive notion of a map-like, or absolute representation of space, and ordinarily depends upon the use of physical objects.

Philosophers sceptical about the idea of the animal representing vectors to and from the centroid should reflect on O'Keefe's startlingly concrete proposal about how this is being achieved. The suggestion is that these vectors are being represented by sinusoidal waves found across the hippocampus. The distance to the cue corresponds to the amplitude of the wave; the angle of the vector corresponds to the phase of the sinusoid. Addition and subtraction of vectors is accomplished by addition or subtraction of the sinusoids (O'Keefe, 1991, pp. 284–5; 1990, pp. 309–11). I am not concerned to question whether an animal could use the kind of scheme described by O'Keefe; it is evident that the thing is possible. What concerns me is whether this is a system which constitutes an 'absolute' or 'objective' way of thinking about space. The crucial point about this model, given our concerns, is that there is evidently no reason why the cues to which it appeals should be taken to be physical objects, rather than stable located features. If this is an 'absolute' or 'objective' mode of spatial thinking, then it is one that has been achieved without any ineliminable appeal being made to the notion of a physical thing.

Do we have here a system which constitutes an 'absolute' or 'objective' way of thinking? Consider, by way of contrast, the Wilkie–Palfrey 'triangulation' model of the behaviour of rats in the Morris swimming task. Here, rats are placed in a swimming pool filled with an opaque liquid. There is a submerged platform to which they learn to make their way. The platform, being submerged in an opaque liquid, cannot be seen by the rats. But they can reliably make their way to it, from any starting point in the pool, so long as it keeps its relation to the distinctive landmarks they can see around the pool. The 'triangulation' model supposes that once on the platform, the animal stores the distances to each of the cues it can see. Then when it next tries to get to the platform, it notes the distances from where it is to each of the landmarks around it. If the distance to a particular landmark is currently greater than it was from the goal platform, the animal swims towards it. If the distance is less than it was from the goal, the animal swims away from it. Its movement is the resultant of all these calculations (Wilkie and Palfrey, 1987). This model is one that O'Keefe himself cites as not truly 'objective', in contrast to the model of slope and centroid. What, then, is the difference between these models? If we look at the matter formally, the striking thing is the extent of the similarity between the models, rather than differences between them. On the slope/centroid model, the vectors to various cues from the centroid are recorded. On the triangulation model, the distances to various cues from the goal platform are recorded. In fact, to improve the parallel, we could consider a version of the triangulation model in which the animal also uses some external compass, such as a gradient in the lighting across the room, to find and record the directions of various cues from the goal platform, as well as their distances. O'Keefe would certainly regard such a model as still falling short of the genuinely objective; but it is strikingly parallel to the slope/centroid model.

It might be said that the parallel is a fake, because in the triangulation model, the vectors to cues from the goal platform are given egocentrically, whereas in the slope/centroid model, the vectors to cues from the centroid are given non-egocentrically. But this way of drawing the contrast cannot be sustained. In the triangulation model, the animal has (a) memory of vectors to cues from the goal platform, and (b) a capacity to put that memory, together with its current perceptions, to use in directing its actions. The memory of vectors to cues from the goal platform is not itself an egocentric presentation of those locations. Rather, it gives information about the positions of things only when put together with the animal's current perceptions and its method of integrating the two. Of course, the memory may be precisely a memory of an earlier sighting of those cues from the goal platform. And that sighting at the time carried egocentric spatial information. But the spatial information that the original sighting carried is quite different to the spatial information that the memory carries. As the memory is used now, it tells the animal where the target is only when it is coupled with information about the current distances to the landmarks. The original perception, however, directly carried information about the location of the target with respect to the cues, without there being any need for such manipulation. We could approach the parallel from the other direction, by considering how the animal using the slope/centroid model might operate. Suppose, for example, that it proceeds as follows. It calculates the slope and centroid of its environment, in the way indicated. It then makes its way to the centroid, and looks about it to find the vectors from it to its various potential targets. In finding these vectors it in effect logs in the content of its current perceptions, proceeding in the same way as the rat on the platform in the water maze on the triangulation model. It might be protested that the animal using the slope/centroid model uses an external compass, namely the slope of the environment, in recording these vectors, rather than its egocentric axes. But we already agreed that the animal using the triangulation model might also use an external compass to log in the vectors to cues from the goal platform, without this transforming its system into an 'objective' representation of space.

It might be acknowledged that there is this parallel between the two models, but a contrast noted too. In the case of the slope/centroid model, the animal uses the vector from it to the centroid, and the vector from the centroid to the cue, to compute the direct vector from it to the cue. In the case of the triangulation model, the animal uses the vector from it to the cue, and the vector from the goal platform to the cue, to compute the direct vector from it to the goal platform. This means that there is a contrast between the role of the centroid and the role of the goal platform. The centroid functions as a means of getting the animal to any target it likes. On the triangulation model, though, the other cues function only as means whereby to get the animal to the goal platform. So unlike the slope/centroid model, the triangulation model is organized around a single-goal destination. This is a relevant contrast between the two models, and one that O'Keefe stresses. But it is hard to believe that it will bear the weight of explaining the notion of an 'absolute' or 'objective' representation. We cannot plausibly say that an 'objective' representation is just a method of navigation which is not dedicated to any single goal. For there are models which are not dedicated to a single goal, yet which cannot plausibly be classified as 'objective'. For example, a system which takes momentary egocentric presentations of the places of things, and uses knowledge of the subject's movements to continually recalculate their current egocentric positions, is of this type (O'Keefe, 1988).

We might press this line of thought in a somewhat different way, though. Perhaps the point is not that the one system is goal-centred while the other is not, but rather that certain types of computation are possible on the slope/centroid model which are not possible on the triangulation model. The slope/centroid model allows one to consider a wider range of spatial relations than does the triangulation model. For example, the triangulation model will not allow one to represent the direct vector from oneself to a currently unperceived cue, even if one has recorded the vector from the goal platform to the cue. But the slope/centroid model will enable one to represent the vector from oneself to a currently unperceived cue. So perhaps the relevant contrast is that the triangulation model is limited in which spatial relations it can represent between the places it represents. Following up this line of thought, we might propose a formal criterion for a way of representing space to constitute a 'map', an 'absolute' or 'objective' mode of thought:

> the system must be capable of representing, perhaps after operations defined within the system, the direction and distance between any two arbitrary represented places.

Or, more generally, since we want to allow for the possibility of 'objective' representations which do not use a metric, but perhaps a more primitive relation of spatial order:

> the system must be capable of representing, perhaps after operations defined within the system, the spatial relation between any two arbitrary represented places.

We can pursue this line of thought by considering the constraint we remarked already on the representation of places. For a creature to be representing places, it must have some grasp of the criterion of identity for places over time. But we can also ask whether it appreciates that the places it represents are all spatially related to each other. And then we can raise the question at what level this conception of the places as all spatially related to each other receives its physical interpretation: How does the animal assign causal significance to the spatial connectedness of its environment? The conception of places as all spatially related to each other has implications for the causal interconnectedness of a region; that there can in principle be causal relations, perhaps of very complex types, between the items represented as being at various places. And now the question is: At what level does the animal register the causal interconnectedness of the space? It can, of course, register the causal interconnectedness of the space through its perception and action. From any point in the space, it can act upon any other. This is the way in which causal interconnectedness is registered in the slope/centroid model. We simply do not have such a full registering of the causal interconnectedness of the space, at any level, in the triangulation model. What we have is (a) from any point in the space, the animal can act with respect to the goal location, and (b) the navigational system being used is one which can, in principle, log in any arbitrary location as the goal location. This is not at all the same thing as a registering of the simultaneous causal interconnectedness of all places in the space. And I think that this is the theoretically interesting distinction between the slope/centroid model and the triangulation model.

Though the triangulation model does not meet the full force of this 'connectedness' constraint, neither does the slope/centroid. What the animal using this system can do is represent the vector from it to any arbitrary target recorded in the system. But it cannot simply represent the vector between any pair of arbitrary places, regardless of whether or not it is thinking of itself as at either of those places. We could, indeed, increase the power of the system, by allowing it to solve 'travelling salesman' problems, in which the animal has to compute the optimum route by which to reach a number of destinations. But this evidently will still not enable it to meet the full force of this 'connectedness' constraint. The animal still has to be thinking of itself as at the start of the itinerary, and as heading for the destination. Further, even meeting the constraint as stated above does not guarantee that the model will capture the full force of the connectedness of the space. The model allows the animal to represent only the geodesics between places. It cannot represent spatial relations of arbitrary complexity between any two places. Finally, the animal is incapable of representing configurational properties of numbers of places: it cannot register the fact, for example, that a particular group of places is configured as the vertices of a regular polygon. It is easy to miss these points because, given a statement of the spatial relations grasped by the animal using the slope/centroid model, a geometer could infer deductively all the other spatial relations that hold in the environment. The animal using the slope/centroid model need not be able to extract any of these further relations from the information it has. The reason why it does not is that its grasp of the physical significance of the spatial information it represents has to do entirely with its concerns in practical navigation, where these further spatial relations have no role to play. So although the slope/centroid model registers a much wider range of spatial relations than does the 'triangulation' model, it does not register the full spatial connectedness of the area represented, because the only way in which causal interconnectedness can be registered by this system is through the creature's use of it in navigation. On the face of it, though, it ought to be possible to represent the causal interconnectedness of a space at another level than through one's own engagements in the space. It ought to be possible to represent the causal interconnectedness of the space by having a disengaged picture of what is going on there. This cannot be done using the slope/centroid model, but it would give us an 'absolute' representation which would be capable of registering the full spatial interconnectedness of a region.

O'Keefe says of the slope/centroid system that it defines 'an allocentric position which is independent of the animal's movements but which can be used to locate the animal's current position' (O'Keefe, 1990, p. 306). Does this mark a contrast between that system and the triangulation model? Here we have to attend carefully to the sense in which the current location of the animal is marked. Even on the triangulation model, the animal using it can be described as finding its own position with respect to the target; realizing that it is to the left of the target, and so on. These are all just ways of describing the the animal's grasp of the vector from it to the target. There is no explicit representation of the animal itself in relation to its surroundings. In particular, there is no representation of the causally significant properties of the animal, such as its capacities for perception and action, and no attempt to explain its current perceptions or what is going on around it in terms of its position and movements. But the picture is exactly the same in the slope/centroid model. There is a sense in which the animal can be said to know where it is with respect to any of its targets; or, indeed, with respect to the centroid. But there is, again, no explicit representation of the animal itself in the system, no explicit representation of its causally significant properties. For there to be such a representation, the animal would have to be thinking of itself as a physical thing. But the animal using O'Keefe's model is not registering the connectedness of the space it is in by thinking in terms of the possible routes of physical objects, such as itself, through that space. The animal is registering the connectedness of the space through the fact of its own engagement in the space, not through reflective thought about its engagement in the space.

4 Causal indexicality

To understand the idea of an 'absolute' representation, a disengaged conception of the connectedness of the space, we need to introduce a new notion. I want to spend the whole of this section explaining this notion. I shall then take up its bearing on the representation of places. We are familiar with the idea that terms may be spatially or temporally indexical, in that their content depends upon where or when they are used. But there is a deeper phenomenon, of causal indexicality, which is what is often being discussed in accounts of indexicality. For many terms which are spatially or temporally indexical are also causally indexical; only this last tends not to be discussed as a separate phenomenon.

A first shot at isolating the phenomenon would be to say that causally indexical terms are those whose causal significance depends on who is using them. But that does not isolate just the class of terms with which I shall be concerned.

Many concepts are causally significant. That is, judgements made using them have some significance for the ways in which the world will behave, and for how it would behave in various possible circumstances. Often, one's grasp of the significance of such a judgement will be, in the first instance, a matter of how one reflectively expects the world to behave, and what counterfactuals one explicitly takes to be true. In such cases, one's grasp of the judgement has to do with the detached picture one builds up of how things stand around one. But there are cases in which one's grasp of the causal significance of a notion has to do not with any detached picture, but rather consists, in part, in one's practical grasp of its implications for one's own actions. These are the causally indexical terms.

I shall give some examples first, before more general description of the class. Although I am ultimately concerned with spatial notions, I shall begin by looking at some non-spatial classifications, to put the spatial cases into context. The easiest way to construct causally indexical terms is by the use of the first person. For example, consider the notion, 'is a weight I can easily lift'. Judgements made using this notion, about whether one object or another is a weight I can easily lift, have immediate implications for my own actions, for whether I will bother to attempt to lift this or that thing. Or again, a judgement such as 'this is too hot for me to handle' has immediate implications for my own actions with respect to the thing; the notion 'is too hot for me to handle', is again causally indexical. These examples might suggest that the distinction here is between notions whose causal significance varies from subject to subject. For example, whether the predicate 'is too hot for me to handle' applies to a thing depends upon who the subject is. But the application of the predicate, 'is magnetic' is not relative to a subject in this way. This, though, does not give us quite the contrast we want. The predicate, 'has the same mass as I do' varies in application depending upon who is using it. But it has no immediate implications for action. The significance for one's own actions of something's having the same mass as oneself depends entirely upon further beliefs that one has, such as whether things having the same mass as oneself will be easy or difficult to lift. We want to separate off those predicates whose causal significance has to do with the immediate implications for one's own actions and reactions to the world.

Let us consider our examples a little further. The predicates 'is a weight I can easily lift', and 'is too hot for me to handle' both use the first person. But intuitively, the use of causally indexical predicates does not depend upon self-consciousness. Even a creature which did not grasp the first person could use causally indexical representations. So there ought to be other examples of causally indexical predicates. Further, these predicates, 'is a weight I can easily lift' and 'is too hot for me to handle', use notions of 'weight' and 'temperature' which we ought to pause over. They need not themselves be causally indexical; they may rather be on a par with a notion such as 'magnetic'. Whether two things are the same weight or temperature, and what their particular weights or temperatures are, may be definable entirely in non-indexical terms. The complex predicates we have constructed may be using non-indexical physical notions to define causally indexical terms. But on the face of it, one might grasp causally indexical terms without having any grasp of these non-indexical notions.

If this is correct, then there ought to be more primitive examples of causally indexical terms. These would not be defined in terms of non-indexical physical notions, and they would not use the first person. It seems immediately obvious that there are such more primitive terms for weight and heat. Unstructured uses of 'is heavy' and 'is hot' may relate to the causal impact of the thing upon the subject, rather than being uses of some observer-independent system of classification. Moving closer to the spatial cases which concern us, a notion such as 'within reach' seems to have immediate implications for the subject's actions. The most immediate effect of judgements made using this notion is that the subject will try to contact things which are within reach, but will not try to contact things which are judged to be out of reach. This predicate is not first-personal. A creature could use representations of things as within reach or out of reach without having the ability to think using the first person.

In ordinary English, there is a certain 'social pull' in our use of these terms. If we say simply that something is 'heavy', that may be heard as having to do not with its relation to one's own powers, but rather to do with its relations to the powers of a normal human; or indeed to its comparison with some reference class of objects of the same general type. I want to set aside this phenomenon. We often do need to consider causal indexicals which have to do simply with the relation of the thing to the subject's own powers. In English, the way in which we make this explicit is by use of the first person. But we may want to use a term so restricted when reporting the reasoning of an animal which is not self-conscious. For example, an animal may reliably perform a task even though we vary a number of parameters, but then give up at some point. The ball has been thrown too far for the dog to recover, the stick is too heavy for it to lift. In such cases we can test for just why the animal is not attempting the task, and we have to be able to say, for example, that it is because the ball seems to have been thrown too far, or the stick seems too heavy. And these notions, 'too far' or 'too heavy', have to do only with a relation to the subject's own powers, even though the animal may not be self-conscious.

In these cases, it is not just that a grasp of the term requires the ability to register when it applies. It is rather that one's grasp of the causal significance of the term is exercised in the way one reacts to recognition that it applies. So, for instance, grasp of the notion 'within reach' is exercised not simply by differentially responding to cases where something is within reach, which might be done by simply looking confident, for example, just when something was within reach, but by the way one moves and acts. Similarly, grasp of the notions 'heavy' and 'hot' is exercised not simply by responding differentially to heaviness and heat, but by differences in the ways in which one prepares to lift something heavy, or to touch something that is hot. We might put the point by saying that one's behaviour makes it evident that one knows heavy things take more effort to lift, or that putting two heavy things together will make the resultant package impossible to lift, rather than less heavy. But this gives an excessively reflective account of one's grasp of the causal significance of heaviness. For there may be a certain lack of generality in a creature's grasp of causal significance here. It may be that it grasps the significance of weight for its own actions, but that there is no possibility of applying the notion in connection with the actions of other creatures. This tying of causal significance to the creature using the notion is characteristic of causally indexical terms.

In the *Physics*, Aristotle gives some early examples. We can contrast a theoretical understanding of the causal properties of particular types of wood, for example, or different metals, such as iron or silver, with the understanding possessed by the carpenter or metalworker. The artisan's grasp of causal properties is not a matter of having a detached picture of them. Rather, it has to do with the structure of his practical skills; the particular way in which he deals with various types of wood, or how he uses different metals. The detached theorist need not have these skills. It is in characterizing the propositional knowledge of the carpenter or metalworker that we have to use causally indexical notions. The subject's grasp of such a notion has to do with his practical grasp of its implications for his own actions. Do we really need to ascribe contentful states to the artisan at all? Surely, it might be said, all that we have here is a set of complex behavioural skills. We should just describe the behaviour and let the content go. This would be the correct procedure if there were just one, or a small set, of concisely describable routines through which the artisan can go. But this is not the case, for someone reasonably skilled. Exactly what the person does depends upon exactly what their goals are. Of course, it is not that the carpenter can do anything he likes with a piece of wood, or that the metalworker can bend his metal to any purpose whatever; but there is no bound on the number of goals that they can in practice achieve, operating in different ways to achieve them. This purpose-relativity of the practical skills means that we cannot give a simple behavioural reduction of them. We do here have genuine content.

The most striking family of causally indexical terms is those which have to do with egocentric spatial classifications – notions such as 'within reach', 'to the right' and so on. And we can contrast them with spatial relations such as 'between', 'adjacent to' or specifications of location using latitude and longitude. A parallel point seems to hold for temporal classifications, for much of what we have said about spatial concepts also applies to temporal concepts. Temporal concepts are also 'theoretical'; they must be given some physical significance, there must be some regularities connecting them with other physical concepts, if they are to be recognizable as concepts relating to the world in which we live. And they can be given this physical significance through a practical grasp of their implications for one's interactions with one's surroundings, though this is not the only way in which it can be done.

There are, however, many other categories across which we can apply this distinction. For instance, we can contrast different ways of thinking of weight. On the one hand, I can classify weights in terms of how well I can lift them, and in what ways – perhaps the weight I can lift depends upon exactly how I try to lift it, or what the shape and size is of the thing which has that weight. If I am trying to carry a bookcase, for example, I might think that I could manage the weight were it not so large and awkward. That is, even within the realm of the causally indexical, there may be some analysis of my abilities to lift things, in terms of causally indexical specifications of weight, cumbersomeness and so on. In contrast, there is the kind of specification of weight used in giving recipes, where there is no reference to the causal powers of the subject. The general point to note here is that causally indexical terms may be theoretically related to each other: they may be connected to action as a body, rather than being related to action on any simple one-by-one-basis.

This does not eliminate the distinction between causally indexical and causally non-indexical terms, though it does mean that we can distinguish between those which have a greater of lesser degree of theoretical interconnectedness. Suppose, for example, that we have a creature which will reach for things it wants which are within its grasp, but which will not reach for these things if they are far beyond its grasp, even if it can see them perfectly well. Suppose someone held that this ability, to reach only when it is worth doing so, must be underpinned by: (a) a non-egocentric representation of the distance and angle between the thing and what is in fact oneself. This representation of distance and angle will not be causally indexical; its causal significance will not be especially for one's own actions with respect to the thing; (b) a representation of the volumetric properties of one's own body, and its reaching abilities, so that one can tell whether that body could reach a thing at the distance and angle from it displayed in (a); and (c) the ability to initiate movements towards a desired object, depending upon whether it was within reach of one's own body, as established under (a) and (b). The problem with this line is that it ascribes a certain generality to the creature's representations, and there may be no warrant for doing this. In the case I just described, the creature is supposed to be representing its own direction and distance from the thing, and using knowledge of its own characteristics to find whether the thing is within reach. There is a generality implicit in this, because the creature is being ascribed knowledge from which it could find whether other creatures could reach for this or that object, given knowledge of their volumetric properties. But there may be no prospect of the creature being able to use its knowledge base in this way. It may be that the notion of something being 'within reach' that we should want to use in characterizing its knowledge is dedicated to its own capacities for movement, and has no potential for application to the movements of other creatures. Its representation of something as 'within reach' may be quite directly tied to its own initiation of movement. The reason for saying that the representation is precisely a representation of something as 'within reach' is entirely its direct relation to the creature's actions.

An egocentric framework for place-identification, such as used in guiding simple actions and defined by the axes left/right, up/down, in front/behind, will evidently be causally indexical: grasp of the causal significance of particular distances and directions will have to do with their practical implications for action. In the case of the 'triangulation' model we considered earlier, the frame is plainly not egocentric – it would most naturally be thought of as centred on the target platform – but grasp of its causal significance is still plainly indexical, and has to do with the animal's understanding of the implications for its own movements.

Suppose we have an animal which is capable of thinking in terms of egocentric frames centred on places other than its own current location, such as the places occupied by other animals, or places which it occupied in the past. Is this animal thinking in causally indexical terms? It depends on how it gives physical significance to the spatial relations it represents. If it did this in a disengaged way, thinking only in terms of the causal relations between the places represented and the creature occupying the place on which the frame is centred, then we would have here a non-indexical mode of thought. If, however, its grasp of these causal relations is ultimately a matter only of the pragmatic implications for its own actions of the way things are with the creature at the other location, or the lessons to be learnt from its own past self, then the mode of thought that we have here is still causally indexical.

Finally, consider the use of a way of identifying places that has to do only with what the subject expects to perceive, not with its action upon the world at all. For example, the child in the Acredolo paradigm considered earlier might be thinking in this 'visually indexical' way. If there is such a 'purely perceptual' mode of spatial thought, it too will be causally indexical: it uses the fact of the subject's interaction with the world rather than the subject's thought about it, even though the 'action upon' component of that interaction has been eliminated. But it may anyhow be impossible to separate grasp of perceptual content from grasp of its implications for action.

I began by posing the question how a creature which did not think in terms of physical objects, but only in terms of causally inert features, could possibly grasp the causal significance of the connectedness of its environment, the fact that every place in it is spatially related to every other place in it. We then remarked that a creature using the slope/centroid model in practical navigation approximates towards achieving precisely that. But this still leaves us without an explicit answer to the initial question. We can now supply that. In our present terms, the point is that for the creature using the slope/centroid model, its grasp of the causal significance of the spatial relations it represents is causally indexical. It is a matter of its practical grasp of the implications for its own actions and perceptions. There is the characteristic lack of generality in its use of the model; it may be quite incapable of ascribing use of the model to any other animal. And the animal need not be capable of representing its own causally relevant properties in a 'disengaged' way, though it may be operating with a 'body-image' directly tied to its own capacity for harmonious movement. So although the features are causally inert, the animal's own interactions with its surroundings can constitute the needed grasp of theoretical significance. So far, incidentally, all we have explicitly considered as giving physical significance to the connectedness of a space is that the way things are at one place should be causally dependent upon the way things were at another place. And in the models we have been considering, that is achieved by the animal navigating itself from one place to another. On the face of it, though, these are extremely rudimentary considerations. Of itself – without looking at the specific manner of causation – this bare causal connectedness would not enable us even to introduce an order relation upon the space, much less a metric. All that we have is a potentially endless number of connections between pairs of places. But in fact, a great deal more structure than this is implicit in those models of animal navigation. This structure is imposed by the fact that we are looking at the career of a single animal, in these causally indexical models. The constraints and structure in the way the animal gets itself around automatically constrain and structure the physical significance of the connectedness of the space. For example, an order relation is imposed by asking, for instance, whether the animal has to pass through *b* when taking the designated route from *a* to *c*. In fact, though, it may be a mistake to look for the most basic kind of spatial reasoning in the use of purely topological concepts. Perhaps the ability to measure spatial intervals is really the primitive ability, and the capacity to reason in terms of purely topological concepts is much more sophisticated. In any case, we can see in outline how an animal could in its use of a navigational system give physical significance to metric properties by using them simply in computing the exact angle to take to get to a particular target, or to find in planning, for example, how much time and effort a journey will consume.

As we saw, the slope/centroid model secures the connectedness of the environment in a stronger sense than does the 'triangulation' model. It can represent the direct route from any place the animal is at to any other place in the environment, not just the spatial relation between the animal and the designated target. But, because of its causally indexical character, there is still a limitation on its capacity to represent the spatial relations among the places in its environment. It is capable of recognizing only the geodesics between places; it cannot represent the spatial relations between any two arbitrary places in its environment, irrespective of whether the organism itself is being supposed to be at one of them; and it cannot represent the configurations of arbitrarily large numbers of places. These limitations are evidently tied to the causally indexical character of the model. It is because of the direct tie of the model to action that the animal is confined to thinking of the spatial relations of places at which it itself might be, and to thinking in terms of geodesics, for example. So if the creature is to transcend all such limitations, it will have to think about the connectedness of its environment in a way that is not causally indexical.

This notion of causal indexicality cuts across the classical distinction between concepts of primary qualities and concepts of secondary qualities, which we could draw somewhat as follows. Terms such as 'electron' are theoretical, in that one could not understand them unless one grasped something of the theory in which they are employed. So, too, grasp of a primary-quality term, such as 'cylindrical', is theoretical; it is just that the theory in question is a much more primitive one, involving such points as 'a cylinder will roll along its main axis but not along any other'; 'cylinders cannot be stacked together without leaving some gaps at the sides'; 'the amount one can get inside a cylinder depends upon its length and breadth'. And so on. The difference between a term such as 'electron' and a term such as 'cylindrical' is that in the case of 'electron' the theory is sophisticated, whereas in the case of 'cylindrical' it is primitive; and one cannot in general spot electrons by unaided observation, whereas one can usually tell immediately when one is confronted by a cylinder. In contrast, in the classical story, in the case of secondary-quality terms, such as 'yellow', there is no associated theory.

Grasp of the term just is having the ability to spot yellow things when one sees them. Yet causally indexical terms are obviously not primary-quality concepts, in this sense, because grasp of their physical significance does not consist just in a reflective grasp of a theory in which they are embedded; even though there are theoretical interconnections among causal indexicals. It consists in a practical grasp of their implications for unreflective action and perception. But the causally indexical terms cannot either be classified as secondary-quality concepts, because grasp of them is not simply a matter of being able to register the presence of a perceptible property. One must have a whole complex of appropriate reactions to the presence of the property. The immediate conclusion is that causally indexical terms are neither primary nor secondary. The question to which I now turn is how to characterize frames of reference which have the genuinely disengaged character of primary-quality concepts as traditionally conceived; which approximate towards constituting an 'absolute' conception, free from any relativity to an agent or observer.

5 Physical objects and intuitive physics

What is the most primitive level at which we could expect to find causally non-indexical notions? One suggestion would be that we have to consider operations with a developed scientific theory, one which somehow resists an instrumentalist interpretation. But this, it seems to me, comes much too late. We can look for causally non-indexical notions at an earlier point. In particular, we can consider the way in which a creature can have and use a simple theory of perception and action; a simple theory of the way in which the world acts upon it and the way in which it acts upon the world. A creature which has such a theory has some reflective understanding of what is going on as it moves around. It has some reflective understanding of the causal relations between it and the happenings it perceives, rather than simply a practical ability to interact with those events. In describing that reflective understanding, we have to bear in mind that the causally significant properties of sentient creatures are rather different to those of inanimate objects. We have to take account of the perceptual systems and capacities for deliberate action the creature has. The most striking causally significant aspects of location are their implications for whether and how the place can be perceived by the subject, and for whether and how it is possible for the creature to act with respect to the place, to avoid it or to reach it, for instance. There are also, of course, the opportunities for mechanical interaction with whatever is at the place, which the creature shares with any other physical thing. This provides a reflective counterpart to the animal's causally indexical thinking; a 'theory' of the animal's own interactions with its environment. But although thinking in terms of a simple theory of perception and action may provide one with causally non-indexical modes of thought about one's relation to one's surroundings, it evidently does not of itself provide one with a richer conception of the spatial connectedness of the places in one's environment than one had already. For after all, these ways of thinking are only reflective counterparts of the causally indexical modes of thought, so they can be expected to register exactly the same range of spatial relations. If we are to capture a richer range of spatial relations than those that are available at the causally indexical level, then we shall have to consider thought not just about the causal relations between the subject and what it interacts with, but about the causal characteristics of what is in its environment, and their relations to each other. In particular, we shall have to look at its thought about the physical objects around it.

Even the most abstract theorist must acknowledge that there are many different types of physical thing. One reaction to the complex diversity of the everyday world is to suppose that our 'intuitive physics' of our environment must be a patchwork of a million different pieces, in which there is nothing identifiable as 'the' role of physical objects: everything depends upon what sort of physical thing we are talking about. Alternatively, it might be held that there is, as it were, a core to our intuitive physics, a central conception of how physical things behave, which becomes overlain with endless more specialized pieces of knowledge (for discussion of this issue see Kaiser et al., 1986, and chapter five). But this issue need not concern us here. For all that we are looking at is the way in which we give theoretical significance to the connectedness of the space we are in, within a reflective intuitive physics. And here it does seem that we can point to structural features of the very notion of a physical thing. Suppose we begin with the rudimentary idea that one way to register the physical significance of the connectedness of a space is through the idea that the way things are at one place may be causally dependent upon the way they were at another place. The internal causal connectedness of physical objects, which is what differentiates them from features, means that they can be used to give physical significance to the connectedness of a space. In particular, the possibility of movement by an object from one place to another means that we can see how the way things are at one place could causally depend upon the way they were at another place. Here we see the role of the ability to re-identify physical things; for the way things are at one place is causally dependent upon the way things were at another place, through object movement, if it is one and the same object that is at the destination as was at the starting-point. To underline the point, we might once again contrast them with located features. As we saw earlier, we can make some limited sense of the notion of the movement of a located feature through a region. We can talk about there being a feature F at place p at time t, and a continuous series of transitions in which there is a feature F at place p' at time t', through a continuum of neighbouring places and times. And we might ask whether we can use this kind of idea to fill out the conception of the way things are, at the place at which the feature ends up being causally dependent upon the way things were at the place from which the feature started. But this would miss a defining characteristic of feature-placing talk: that features are precisely not thought of as having that kind of internal causal connectedness. So this kind of transition does not give us a way of registering the physical significance of the causal connectedness of a space. Just because features lack the internal causal connectedness characteristic of physical things, this series of transitions does nothing to establish a causal connection between one place and another. As we saw, a grasp of the causal significance of the connectedness of a space can be achieved by a creature thinking only in terms of located features, but this is achieved only through the use of causally indexical thinking. At the moment, what we are trying to understand is how the physical significance of connectedness could be grasped by a creature using a causally non-indexical intuitive physics – an 'absolute' representation of its surroundings. And it is here that located features cannot help.

Another aspect of the role of physical objects here is to say that they are, as it were, the 'units' of causal connection and interaction in our intuitive physics. This is brought out by the fact that we suppose physical objects move, in general, independently of one another; movement together is, on the face of it, evidence that we are dealing with but one thing (see chapter five on 'the principle of contact' and the 'principle of cohesion'). When we consider the movements of objects through a space as causally connecting one place with another, we can, by further considering the details of that movement, see how to give physical significance to the metric for the space, within our intuitive physics. The crucial notion here will be the time taken for the thing to reach a particular destination from a particular starting-point, given what sort of thing it is and what causes are affecting its motion. There are, indeed, further constraints which are imposed merely by the fact that the object movement is continuous. If it could happen that objects moved discontinuously from starting-point to destination, it could still be that differences in the times taken for them to do so enabled us to give some theoretical significance to the use of a metric. The continuity of object movement means that an order is imposed on the places between the starting-point and the destination, depending on what trajectory we assign to the object; and this in turn is responsible to our conception of the causes of its movement. These remarks only begin on the structure given to the space of our intuitive physics by the role of physical things. There are, of course, many further phenomena which in diverse ways transmit the effects of things being thus and so at one place, to their being thus and so at another place. For example, there are the everyday phenomena of magnetism, heat and cold, the flow of liquids, and the winds. One fundamental range of alternatives to physical objects emerges if we consider mariners navigating in a vast circuit of tides, whirlpools, eddies and currents. It is, in principle at any rate, open to them to register the physical significance of the spatial connectedness of the region they are in without exploiting the fact of their own navigation through the space, or introducing the notion of a physical object. The waves themselves, propagated throughout the space, and interacting with one another in endlessly complex ways, demand for their understanding a rich grasp of the connectedness of the space. And to some extent we can, in our common-sense understanding of the world, use this kind of causal thinking on land, if we watch the effects of an earthquake, or the impact of a hammer-blow on the wall of a house. But these phenomena are not sufficiently pervasive in ordinary experience to provide the full strength of our grasp of the theoretical significance of the connectedness of the space we occupy.[7]

The kind of physical-object reasoning I have described shows how we can give theoretical significance to the connectedness of the space we are in at an 'absolute' or causally non-indexical level. As I said above, the obvious way to achieve a causally non-indexical representation is through reflection on one's own interactions with one's surroundings. The question that now arises, though, is whether there could not be a creature which had a causally non-indexical representation of its surroundings, through physical-object reasoning of the kind just indicated, but which did not reflect on its own interactions with the environment. The question is whether there could not be a subject who thought in a causally non-indexical way about physical things, as outlined above, but who had no conception of its own causally significant properties. So this subject would have no simple theory of perception and action. This subject would be in a rather peculiar position. We want causally indexical spatial thinking, of the kind which one might use in simple navigation, to be capable of serving as evidence in the construction of a causally non-indexical description of the layout of one's surroundings. And the causally non-indexical representation itself must ultimately be capable of affecting one's actions. But the subject we are considering would be using the causally indexical evidence to construct a non-indexical representation, without using the information to build up any picture of its own relation to its surroundings, though it could still be interacting with them. We can form some sense of the way the world would seem to this subject by using the analogy of someone watching a documentary film. Such a film is not ordinarily shot to display the autobiography of a single person. Indeed, in watching the film one might not even raise the question of how it was shot: how the camera angles were achieved or, indeed, whether a camera was used at all. One might simply watch what is happening. And one might build up some picture of the space in which the action is taking place, and the interactions of the objects in it. The subject we have to consider is someone who views his or her own perceptions as being in some ways like such a documentary. He builds up a picture of the space, and the kinds of objects in it. And he can use his perceptions in guiding his actions, in visually guided reaching for example. But at the reflective level, he simply does not raise the question how he is acquiring this information. He simply watches what is going on, and builds up an 'absolute' or causally non-indexical representation of it all.

This issue is connected to the question whether we can in the end make sense of the conception of a causally non-indexical or 'absolute' level of thought at all. To anticipate, the connection is that the physical-object reasoning only has any claim to be reckoned as causally non-indexical if it is embedded in a simple theory of perception and action; but the point needs some elaboration. Let us begin with the question whether we can make anything of the idea of a causally non-indexical or 'absolute' level of thought. In one way this is a familiar issue. One formulation of realism is precisely as the thesis that there is such a level of thought. And one way to formulate the anti-realist challenge is as the claim that there is no such 'absolute' level of spatial thinking. It is often said that we can characterize realism as the thesis that a statement may be true even though it is in principle impossible for us to tell that it is true (McDowell, 1976; Wright, 1987; Peacocke, 1986, p. 86). This has the characteristic deficiency of modal formulations of philosophical theses: that what matters for the truth of the thesis is not the modal claim itself, but the ground of the possibility. What matters for the truth of realism is how it might happen that a statement could be true even though we could not tell that it is. On the face of it, an anti-realist might hold some such modal thesis. One might hold that reality is a human construction, while maintaining that it is not, point by point, a human construction; rather, as an artefact of the general construction process used, it may be that some statements have their truth-values determined, even though we have in principle no way of finding out which truth-values we have determined them to have (Kreisel, 1969, esp. p. 148). Or again, consider the position of a realist who holds a radically externalist view of the mind, on which it is sufficiently receptive to its environment that it can find out about any environment in which it is embedded. This view can hold that the plasticity of the mind means that any truth can be known; but it is not thereby an anti-realist position. The notion of an 'absolute' or 'objective' way of thinking about space, used in the context of a theory of perception, gives us a distinctively realist way of describing the ground of the possibility of recognition-transcendence, because after all, a statement may be true even though no one was appropriately positioned to observe its truth. Our 'film' subject, who thinks at a causally non-indexical level about what is going on, without having the wherewithal to formulate its independence from his perception of it, may nevertheless still seem to have grasped something of the categorical basis for the possibility of recognition-transcendence, in a distinctively realist way (Dummett, 1991).[8]

The really deep issue here is whether one's grasp of causal relations has to be understood ultimately as deriving its content from its connection with causally indexical terms; whether the notion of causality has to be understood exhaustively in terms of its connections with one's own actions and reactions. The thesis that it does is the same as the thesis of anti-realism about the spatial world. For the realist, the general philosophical interest of the notion of 'absolute' space, and the correlative notion of causal non-indexicality, is that it seems to be here, in their use in the context of a simple theory of perception and action, that we have our most primitive form of distinctively realist thinking. This way of formulating the issue of realism gives a new role to the anti-realist argument which Michael Dummett has developed. This argument presses hard such questions as: 'In what does our grasp of meaning consist?' (see Dummett, 1976). Suppose that we are considering whether we have a grasp of causation that does not consist in a practical grasp of how one ought to behave. Here, it is exactly the meaning-theoretic argument that seems most pertinent. What would it be to grasp this 'objective' causality? Would there be any behavioural difference between a creature which thought only in causally indexical terms, and a creature which had a grasp of causally non-indexical notions? If not, can we say that there is any difference between these creatures at all? I do not think that this line of argument can in the end be correct; but it is obviously urgent. The shift away to thinking in terms of causation has the further advantage, from the point of view of a proponent of the meaning-theoretic argument, that the argument need not keep the restriction to considering only assent/dissent behaviour; it is quite implausible that all our grasp of meaning can be characterized in terms of assent/dissent behaviour. Shifting to the formulation in terms of causation, the proponent of the meaning-theoretic argument can consider the full range of ways in which we interact with our environment, while maintaining urgent pressure on the realist.

It does not seem essential to thought of physical objects as such that one should be thinking in causally non-indexical or 'absolute' terms. Consider a cat chasing a mouse, for example, or watching a bird flap its wings and fly off. It is unquestionable that the internal causal connectedness of the thing shows up in the cat's representation of it – it is thinking of the thing as an object – but the internal causal connectedness shows up in the way in which the cat itself interacts with the thing, in perception of it or in acting upon it. There is no need for the cat to have any disengaged picture of the causal characteristics of the thing. Even though we can grasp the internal causal connectedness of other objects while thinking in causally indexical terms, however, the strategy seems much harder to apply to one's own case. When one is, in causally indexical terms, putting to work the internal causal connectedness of the things around one, the way in which one does it is by exploiting one's own interactions with those things; although one need not think of these interactions in fully self-conscious terms. On the face of it, this strategy will not work for one's own case. The kind of interaction described above cannot show that the cat is self-conscious; that it conceives of itself as one physical object among many. The point about the 'film' subject is that this subject cannot in this way make out its claim to be engaging in thought which is causally non-indexical. The 'film' subject has no way of resisting the charge that his thought about his environment is not after all causally non-indexical, for he lacks the conception of himself as a physical thing in interaction with his surroundings. And the very hardest case for the anti-realist reduction of the causally non-indexical to the causally indexical is the case of one's reflective grasp of the interaction between oneself and one's surroundings.

On one conception of it, self-consciousness depends upon the capacity for thought at a causally non-indexical level. On this conception, to be self-conscious is to be capable of thinking of oneself as having the internal causal connectedness characteristic of physical objects (Neisser, 1988, esp. pp. 46–50). And that conception of oneself cannot be exercised through unreflective interaction with one's surroundings. This is, so even though the conception of other things as physical objects can be exercised through one's unreflective interactions with them, as we saw in the case of the cat and its prey. It is evident that no amount of such unreflective interaction would enable the creature to exercise the conception of itself as internally causally connected. To exercise that conception one must be capable of thinking reflectively about one's own interactions with one's surroundings. One must have some grasp of one's own causally significant properties, and how they interact with the things around one. Centrally, one must have some conception of how where one is affects what one can perceive. And one must have some conception of how it is that one affects one's surroundings – what kinds of actions one is capable of. One must, in short, have at least a simple theory of perception and action in one's grasp. Kant's insight, to which Wittgenstein was faithful throughout his career, was to recognize that realism and self-consciousness are inseparable problems. One aim of this chapter has been to display something of why that is so.

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NOTES

1 For discussion of this more primitive 'feature-placing' use of language, see Ayer, (1973, pp. 89–93); Dummett (1973, pp. 232–4 and ch. 6 'Identity', esp. pp. 562–83); Dummett (1981, pp. 216–19); Evans (1985a and 1985b); Quine, (1974, §15, 'Individuation of Bodies'); Strawson (1959, ch. 7) and Strawson (1971).
2 For a discussion of the mass/count distinction see Quine (1960, §19).
3 On origin and identity cf. Kripke (1980, pp. 110–15) and Forbes (1985, ch. 6) for subsequent discussion.
4 For a review discussion of pigeon homing see for example Gallistel (1990, pp. 144–8).
5 For this view of content-ascription see Millikan (1984).
6 See also Wehner, et al. (1990, pp. 479–82); Menzel et al. (1990); Gallistel (1990, pp. 123–40), for a review of Gould's work on the map hypothesis for bees. The original paper is Tolman (1948).
7 For further discussion of spatial aspects of our intuitive physics, see Hayes (1985, esp. pp. 18–30); Hayes (1990, esp. pp. 187–95); McCloskey (1983a); McCloskey et al. (1980) and McCloskey (1983b).
8 The deep and difficult question which remains is to relate this conception of realism to the formulation given by Michael Dummett (1991).

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