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Spatial Language

Intermediate article

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CONTENTS

The study of spatial language is concerned with the systematic properties of spatial descriptions in natural languages, that is, the description of where things are, or the description of moving bodies.

SPATIAL COGNITION AND LANGUAGE

There are two reasons why the study of spatial description in language might be of special interest to cognitive science. First, space is a central cognitive domain for any roving animal, and human thinking is deeply spatial, reflecting no doubt this ancient phylogeny. The role of gestures, figures and diagrams, geometry, and maps in our thinking all attest to this fundamental role that spatial thinking plays in our cognition. In linguistics, this idea that spatial notions form the foundation for much of our nonspatial concepts is known as 'localism', much evident in cognitive linguistics. Second, language seems to offer a window on the inner world of spatial concepts – in the case of the honey bee for example, we know more about spatial cognition from the communication system than from direct observation of other behavior. However, optimism that we might find a uniform core of human spatial communication may be misplaced: due to the complexity of human cognition, the conceptual systems that underlie language display little of the metric precision of our perceptual systems and are quite variable, being deeply interlocked with cultural concepts (see Bloom *et al.*, 1996). They must therefore be studied in their own right, even though it turns out that there are close interrelations between nonlinguistic spatial cognition and linguistic concepts. (*See* **Spatial Representation and Reasoning**; **Spatial Cognition, Psychology of**; **Spatial Disorders**; **Cognitive Linguistics**)

In a tradition that goes back to Kant and beyond, an orthodoxy has grown up that holds that naive human spatial cognition, as reflected in language, is universally egocentric and anthropomorphic in character, and characterized by such universal primitives as ON, IN, AT, and so forth (see e.g. Miller and Johnson-Laird, 1976; Lyons, 1977; Herskovits, 1986). Such spatial concepts are often put forward as good candidates for innate concepts, reflected universally in language (see e.g. Landau and Jackendoff, 1993). Readers are left with the impression that such notions as 'to the left of', 'in front of', 'on', etc., are universally expressed, and moreover that they are coded in limited parts of speech, especially adpositions (prepositions and postpositions). This impression is deeply misleading – recent cross-linguistic work shows that there is no such uniformity in either the semantics or the formal expression of spatial distinctions across languages. This article details these more recent findings, and their consequences for the language–cognition interface.

THE SEMANTICS OF SPACE

Fundamental Concepts

The details of the semantics of spatial description are quite complex and vary considerably across languages, but the general outlines tend to follow rather simple functional principles, as follows (see Levinson, 1996 for details). The Newtonian concept of space as an infinite, abstract three-dimensional envelope plays relatively little role in naive spatial conception – rather, the Leibnizian view of space as a system of relations between things is predominant (some exceptions are noted below). In particular, one object, the *figure* (or theme or trajector, in alternative terminologies), is located by reference to another, the *ground* (or the landmark or relatum). When figure F and ground G are contiguous, it is often sufficient to say in effect 'F is at G', where 'at' glosses some kind of contiguity relation. However, languages may subdivide contiguity into different kinds of relation, such as superadjacency, subadjacency, containment, and so forth (as in 'The ball is on the table/under the cloth/in the bowl'). This kind of relation is called *topological*, following Piaget. Where G is relatively large compared to F, it may be helpful to subdivide G into parts, and say in effect 'F is at the X-part of G' (as in 'The book is in the back of the car'). Place-names or *toponyms* may be thought about as an elaborate subdivision of a territory for just this purpose. (*See* **Piagetian Theory, Development of Conceptual Structure**)

When F and G are displaced in space, a more complex solution to spatial location is required: we now need an indication of the direction from landmark G in which to search for F. To specify a direction, we need an angular specification, and natural languages provide this in *polar* (rather than Cartesian) *coordinates* mostly based on G. Such coordinate systems are called *frames of reference* in the psychological literature, and it turns out that languages use just three main types. One type uses the system for partitioning objects into parts already mentioned, and projects an axis from the centre of G through a named part to determine an angle or direction, specifying in effect 'F is to the X-side of G', as in 'The ball is at the rear of the truck'. This kind of coordinate system is called the *intrinsic* frame of reference because it relies on reference to the inherent or intrinsic parts of objects (although this terminology is misleading – different languages have quite different ways of assigning parts to objects). Another type uses the bodily axes of the viewer, front and back, left and right, and maps this coordinate system onto the landmark object G, so that we can talk, for example, of F as to the left of G (the mappings are subject to different transformations in different languages, as will be explained). This kind of system is called the *relative* frame of reference (it is often also called the *deictic* frame of reference, but this is misleading, as the viewer whose bodily coordinates are used need not be the speaker, and all frames of reference can have the speaker as the ground object). The third and final kind of system uses abstract, antecedently fixed bearings, a bit like our North or East. Such systems are called *absolute* or 'geocentric' or 'environmental' frames of reference, and all languages use such a system in the vertical dimension, as in 'The lamp is above the table'. But it has only recently been documented that some languages use such systems on the horizontal plane to the exclusion of the relative frame of reference (see Levinson, 1996; Pederson *et al.*, 1998).

The properties of motion description are somewhat different. Motion can, of course, be described as located in a place, in which case the systems already mentioned are relevant, but normally the interest is in the direction of motion, or at least in where it is originating or terminating. Again we talk about the figure (the object in motion), but we may need to distinguish multiple grounds, especially the *source* and *goal* of the motion. The specification of source or goal alone does not give us an angle or vector of motion (a fully specified direction) – it only tells us that the motion progressively increased or decreased the figure's distance from the landmark or ground object (a radial trajectory towards or away). Source and goal together do fix a vector, as in 'He went from London to Birmingham', but many languages do not permit source and goal specification in one clause. Languages which use the absolute frame of reference often use fixed bearings to determine a vector, roughly as in 'He left the village northwards'.

One omnirelevant location is the place of speaking, the *deictic centre*. This location may be the ground in any location or motion description, and in principle it is not different from any other landmark, but in practice languages tend to code it specially, for example in demonstratives ('this' versus 'that'), deictic adverbs ('here versus there'), and deictic verbs of motion ('come' versus 'go', 'bring' versus 'take'). (*See* **Indexicals and Demonstratives**)

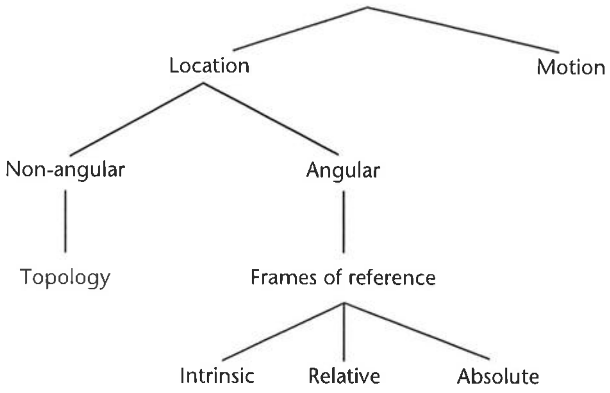

Figure 1. Some important subdomains of spatial language.

Languages tend to treat space as a single large semantic field; for example, most languages have a single shared root meaning 'Where?' used across topology, frames of reference and motion description. But this large field tends to be systematically subdivided, so that motion versus location, and within location topology versus frames of reference, are distinguished as important subdomains organized distinctively in both form and meaning, as in Figure 1, and linguistic descriptions should treat these subdomains individually.

Cross-linguistic Variation and Underlying Universals in Spatial Language

Recent investigations have shown that there is much more cross-linguistic variation in spatial language than had been supposed. The semantic parameters involved can be quite various and differently interconnected. Consider first the distinction between location and motion – Talmy (1983) argued that these are deeply interlocked, and indeed location can be thought of as a special case of motion (consider e.g. the parallelism of English 'He is out of the room' versus 'He went out of the room'). However, many languages use entirely different semantic and formal resources in these two domains, so that no such parallelism can be presumed.

Consider the topological subdomain. As mentioned, many authors have presumed that notions like ON, IN, and AT would be universally coded in adpositions (capitals here denote supposed semantic primitives). But in fact there are no easy generalizations of this kind – for example, central Australian languages often conflate IN and UNDER, Japanese conflates ON and OVER, and they do so in different parts of speech, spatial nominals and postpositions respectively. However, variation is not random. Detailed comparison of many languages using standardized stimuli shows that the topological subdomain seems to form a single, universal multidimensional similarity space – the space is very variably subdivided by different languages, but in doing so they conflate into single lexical concepts only neighboring spatial relations. The semantic parameters in this space are at a much more abstract or componential level than ON; if that is conceived of as unattached contact with the vertical support provided by a horizontal surface, then it is notions like *contact, adhesion, superposition, horizontal supporting surface* that form the dimensions of the space. Moreover, these notions are encoded in various parts of speech in different languages: in grammatical case, adpositions, spatial nominals (special minor form classes of nouns), and frequently in locative verbs. Many languages have a small form class of locative verbs, the choice of which makes distinctions concerning the shape and orientation of the figure and its relation to the ground, and some languages have large sets of such verbs that code detailed figure–ground configurations, such as containment within a bowl-shaped ground, or wedged between two supports, as in Tzeltal.

Turning now to the ways of indicating angular direction between figure and ground, the intrinsic frame of reference is by far the most widespread of coordinate systems – indeed a case can be made for the intrinsic frame being universal, at least in vestigial form. However, the way in which objects are partitioned and assigned named sides or facets is very variable. Some languages (like Zapotec) use a fixed armature, assigning a 'top', 'bottom', and designated 'sides' (one can think of this as a superimposed box, as it were, where 'top' is always the vertically uppermost surface). Some languages (like Tzeltal) use an orientation-free system of internal object geometry: the longest axis has names associated with the end faces according to their shape, and similarly for the secondary axis, and so on. Such a system is intriguingly like the system David Marr (q.v.) imagined must be involved in visual object recognition. Yet other languages like English involve a complex mix of orientational and functional criteria, so that the 'top' of a bottle remains the 'top' whichever way up the bottle is (unlike in Zapotec), but the notion is tied to canonical orientation of the artifact. Miller and Johnson-Laird (1976, p. 403) sketch an algorithm for such part-assignment in English, involving such factors as the leading facet in typical motion (the 'front' of a truck), the facet with perceptual apparatus (the 'front' of a camera), the characteristic orientation of the user to the object (as in the 'front' of a desk). Despite the evident complexities, children learn the application of these terms in English earlier than other spatial relations.

The relative frame of reference involves, as mentioned, mapping the body axes, front/back, and left/right, onto the ground. Despite the fact that Kant and many other theorists have assumed the primacy of these axes in our naive spatial conception, many languages make no systematic use of them in this way – that is, they have no locutions of the kind 'The boy is behind the tree' or 'The boy isleft of the tree' (note that such a language may have a term for 'left hand' but makes no generalization of this concept to spatial regions). Many Australian and other languages around the world are of this kind. When languages do provide such locutions, the interpretations can be very various. Note that in English, the 'front' of the tree is the side facing the speaker or observer, thus rotating the speaker's front and back, while 'left' and 'right' are not rotated. One interpretation of this is that the observer's body axes are mapped under reflection onto the ground. In contrast, in Hausa and many other languages, the observer's axes are translated without reflection or rotation, so 'left' and 'right' remain as in English, but 'front' and 'back' are reversed – 'The boy is behind the tree' now means the boy is between the speaker or observer and the tree (yet the term 'behind' applied to myself means just what it does in English). Hausa thus adopts the convention that the speaker and the tree are in single file, as it were, while English acts as if speaker and tree were confronting each other. Finally, in a few languages, full rotation of the axes occurs under mapping onto the ground: now the 'front' and 'back' of the tree are as in English, but 'left' and 'right' are reversed.

These relative systems may originate as generalizations of the intrinsic system onto ground objects such as trees which are not easily assigned 'fronts', 'backs', or other facets. This would account for the fact that relative systems always occur with associated intrinsic systems, and like intrinsic systems are largely coded in a series of nominal expressions. Thus in English 'The boy is in front of the tree' is unambiguously relative, but 'The boy is in front of the truck' is ambiguous between the intrinsic reading (at the front end of the truck) and the relative reading (the boy is between the observer and the truck). But many languages do not allow this ambiguity – if there is a possible intrinsic interpretation, then that pre-empts a relative one. The ambiguity in English has prompted theorists to assume that the terms themselves are not semantically specified one way or the other, and that frames of reference are psychological in character, not linguistic (Miller and Johnson-Laird, 1976, p. 404). But in many languages the intrinsic and relative systems are clearly distinct in construction, and in English the distinctions can be made linguistically (as in 'at the truck's front').

The absolute frame of reference used on the horizontal plane will be unfamiliar to most readers except in discourse about geography, where *North* may really be thought about as 'up' on a map, that is, intrinsically. However, many languages use an absolute frame of reference for nearly all spatial discriminations for objects separated on the horizontal plane, speaking thus of 'the northern knife' or 'your western knee' and so forth. There are again many different types. Some languages, like most Australian Aboriginal ones, have fully abstract cardinal direction systems, like our North, South, East, and West, except that they may be skewed in different directions and are likely to have precise quadrants or arcs associated with each. Orthogonal axes are normal, but not invariable, and quadrants of application may be equal (of 90 degrees) or not. Another common kind of system (found e.g. in Nepal and MesoAmerica) uses major inclines in local geography, with an uphill versus downhill major axis, and an 'across' minor axis (the directions further specified by landmarks). A third common type of system (found e.g. in Arnhem Land and Alaska) uses the major axis of river drainage to provide 'upstream'/'downstream' and 'across' axes. Prevailing winds are also a common source of inspiration, as in Eskimo wind direction systems, which in naming up to sixteen directions around the compass card allow precise subdivisions down to 22.5 degrees. It should be stressed that although these latter systems may seem hooked to local environmental conditions, these systems are mostly abstracted off this ecological background, and have become fully abstract fixed bearings, which do not vary when the landscape varies or when used outside traditional territories. Such systems often have considerable linguistic importance, forming a systematic underlying set of oppositions, a grammatical category, which shows up in different lexical and morphological sets – for example, such languages are likely to have, in addition to nouns denoting the directions, motion verbs meaning 'to go north', etc., and demonstratives meaning 'that northern one', etc.

Incidentally, absolute systems of spatial description are the only naive spatial concepts that seem to surpass in abstraction the Leibnizian view of space as consisting only of relations between things. A description such as 'the southern edge' or 'going east' does not rely on a figure–ground relation – instead of the relation to the ground an abstract spatial vector is specified in a Newtonian space. In addition to this abstract quality, these systems are of considerable interest to the cognitive scientist because they require speakers of such languages to constantly and correctly reckon their orientation with respect to these fixed bearings, a point that we will return to.

Clearly not all languages use all three of these frames of reference (intrinsic, relative, and absolute), but some do. Some languages use the intrinsic system alone, and others use the absolute system alone, or with only traces of the intrinsic system. The only constraint appears to be that the relative frame is dependent on the intrinsic one. This relative freedom of occurrence is intriguing, since the different frames have rather different spatial and logical properties. For example, unlike the intrinsic frame, both the relative frame and the absolute frame map axes from a larger space onto the figure–ground relation – hence when the figure–ground configuration is rotated, the intrinsic description may remain constant, but not the relative or absolute descriptions. Relative and absolute frames thus support logical transitivity and converseness (e.g. if A is north of B, and B is north of C, A is north of C), unlike the intrinsic frame. However, if one rotates the viewpoint (e.g. by walking around to the other side of the array), the figure–ground relation changes in a relative description (what was to the left becomes to the right), but not in an absolute description. Thus it is only absolute descriptions that sustain full logical inferences under different viewpoints – they are clearly the logically superior systems, but require a significant cognitive overhead, namely constant mental orientation.

In summary, then, the semantic distinctions made in spatial descriptions vary quite widely across the world's languages, and there are no high-level concepts of the order of IN or FRONT OF or LEFT OF that turn up universally in languages. Nevertheless, there seem to be underlying constraints on the semantic spaces involved in each subdomain, such that, for example, the topological space seems universally specified as a single similarity space, languages can draw from only three frames of reference, each based on polar coordinates, and so on. Another area of surprising diversity is the way in which such distinctions are coded – there are no universal tendencies for spatial relations to be coded in just one or two parts of speech, but rather the tendency is for spatial information to be distributed through the clause, in nominals, case, adpositions, and spatial predicates.

THE COGNITIVE CONSEQUENCES OF LINGUISTIC DIVERSITY

Many species (ants, bees, fish, birds, and bats) have quite extraordinary spatial and navigational skills, often based on such exotic senses as polarized light detectors, echo-location, and magnetoreceptors. All the evidence points to native human spatial perception as being indifferent to poor, as generally in the primate order. Western subjects, for example, displaced to an unfamiliar location, can rarely point to home-base, or even a recent waypoint, at much better than chance levels.

The diversity of linguistic systems for spatial location points to the special role that culture plays in human spatial thinking. The same point is suggested by the elaboration of different navigational traditions and by the technological development of a prosthetic sense of direction through maps, compasses, and satellite systems. The acquisition of spatial language by children also suggests that most spatial concepts in language are anything but 'natural', being learnt relatively late. The facts of acquisition, as far as we now know them, are as follows. Western children clearly learn topological spatial terms first, starting at about age two, proceed to intrinsic uses, and about the age of four have relative usages of 'front' and 'back'; but 'left' and 'right' terms lag far behind, with relative 'left' and 'right' often not being fully mastered before 11. This development is in line with predictions from Piagetian Theory, where topological concepts are held to be conceptually simpler than the Euclidean geometry underlying frames of reference. But children whose native languages have fundamentally different spatial systems from European languages do not seem to start from a common universal notional core, and then gradually diverge – rather they seem to adapt to the local system of categories from the beginning (Bowerman and Choi, 2000). Thus some children learning languages with intrinsic and absolute frames of reference, but no relative frame, do not seem to learn the intrinsic system before the absolute one, but rather at the same time or even partially in reverse order (Brown and Levinson, 2000). All of this suggests that in this domain the child must construct the relevant categories – they are not given by innate endowment as some authors have supposed. (*See* **Navigation**; **Piaget, Jean**)

Nevertheless, cultural and linguistic concepts of space can be shown to have profound cognitive consequences. For example, speakers of languages where the absolute frame of reference is predominant must run a constant background mental computation of absolute direction, reproducing in cultural 'software' what ants and bees do in 'hardware' through specializations for solar compass estimation. Pointing experiments show that such peoples, in contrast to speakers of relative languages, are capable of great accuracy in direction estimations without special attention during motion. Further, experiments on nonverbal memory and inference on these same subjects show that they code spatial scenes in memory in terms of fixed bearings, and not in terms of, for example, left and right, as Western subjects do. This can be shown using the distinct properties of relative and absolute frames of reference under rotation – for example, if subjects are shown an arrow facing left and south, are asked to memorize it, and are then rotated 180 degrees, and asked to pick the similar stimulus from a pair of arrows, one facing right and south, and one left and north, speakers of relative languages will pick the north-facing arrow because it preserves leftness, but speakers of absolute languages will pick the right-facing arrow because it preserves southness. When embedded in a reasoning task, such manipulations are good tests for unreflective coding strategy, and the results show systematic effects of the semantics of the native language on the subjects' mental representations for general reasoning (see Levinson, 1996; in press). These are among the strongest Whorfian effects of language on cognition that have been demonstrated. (*See* **Whorf, Benjamin Lee**; **Linguistic Relativity**)

As mentioned at the beginning, spatial thinking seems to play a special role in human thinking. Further evidence of this comes from a pervasive phenomenon associated with speaking, namely gesture. Although the functions of gesture are not fully understood, it is clear that gesture co-occurs especially with talk about space, and although part of the motivation is communicational (especially in the case of pointing), part is conceptual – gesture seems to help the formulation of spatial messages (see McNeill, 2000). Interestingly, absolute speakers gesture while retaining the correct bearings of events, while relative speakers tend not to, indicating shared frames of reference in language and gesture. Finally, a matter of special interest is the encoding of spatial information in languages coded in a spatial medium, namely sign languages, where it turns out that there is no single, 'natural' solution to the depiction of space. (*See* **Sign Language**)

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