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VECTORS, VIEWPOINT AND VIEWPOINT SHIFT:

TOWARD A DISCOURSE SPACE THEORY

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1 Introduction: principles underpinning Discourse Space Theory (DST)

Many, at least outside the generativist tradition and even some inside it, have thought that spatial perception and cognition is of fundamental relevance to the human mind, and thus to the human language system. This point needs to be taken seriously, if we are to understand what it is to be 'situated' and 'embodied', in the sense that cognitive linguists often use these terms. The Discourse Space Theory (DST) outlined in the present paper starts with space, Euclidean three-dimensional space as it is, or may be, represented by the human nervous system (cf. O'Keefe and Nadel 1978, O'Keefe and Burgess 1996, Gallistel 1990, O'Keefe 1996, 2003, Gärdenfors 2000). This stance has two important implications. The first is that in order to model and explore the way language is grounded in the experiential situatedness of human individuals, we need a notation with which to work. The second implication is that any such notation will need to be *well motivated*, by which is meant here that it will need to be more or less directly linked with the way we model the behaviour of human cognition and perception in general.

For some time now propositional logic, symbol manipulation and linear algorithms have given way to connectionist modelling in cognitive science. Within cognitive linguistics connectionist models have been developed for metaphor and constructions (cf. Feldman, (1989), Regier (1996), Bergen and Chang (2002), Shastri (2002), Feldman and Narayanan (2003)). The present approach, however, goes down a slightly different route in the pursuit of some formal means of representing speaker-hearer orientation, embodiment and situatedness. This is not to say that the perspective developed here may not be tractable in neural network theory. However, for the level that we wish to model, namely the representation of situated and embodied discourse, there are reasons to think that it is geometry that is the relevant instrument. This is not a novel approach in cognitive science. Abstract geometry and topology have been used to model language phenomena by Thom (1970) and Petitot (e.g. 1995). Gallistel (1990) argues that low-dimensioned geometries are fundamental in the mammalian nervous system, and Gärdenfors (2000) argues for the geometrical representation of conceptualisation.

The main of aim of this paper is to propose that rather simple vector geometry in variable coordinate systems allows us to model some fundamental properties of human discourse. And the focus is indeed on *discourse*—that is situated, embodied and speaker-oriented linguistic performance, rather than on non-situated linguistic knowledge. One way of seeking to justify the proposal is to investigate the extent of its efficiency for capturing the discourse data—the usual procedure for any proposed linguistic theory (or any other theory, for that matter). This is what this paper will seek to do, at least for a sample area of discourse phenomena. However, it has long been argued (cf. 'explanatory adequacy') that this is not enough, and in cognitive linguistics, we should perhaps want our descriptive apparatus to go some way towards interfacing with the descriptive approaches of neighbouring sciences, such as cognitive science and neuroscience.

This does not mean that cognitive linguists need to be specialists in two disciplines, but it does mean that we should try to propose descriptive means that can be assessed by the appropriate specialists. One way to do this, of course, is to use the common language of mathematics, in the present instance the mathematics of space, namely, geometry. For the study of discourse itself, this paper argues that there are advantages in thinking in terms of coordinate systems, one of the key advantages being that this enables us see the individual cogniser and speaker as *situated* at the intersection of different dimensions. What the DST model itself consists of is an *abstract* three-dimensional space in which we use geometric vectors[1] to represent not only spatial locations but also movements,

[1] I stress *geometric* vectors. High dimensional abstract vectors are essential to connectionist models of language (NTL, LSA). But the present approach stresses elementary geometric vectors of modest

and, what is more important and also more speculative, to represent semantic configurations that can be viewed as *derived* from spatial concepts. A property of coordinate systems, which we shall make use of, is that they can be transformed: that is, the origin can be shifted relative to the base set of coordinates. There may be limitations in what we can do in this way. In general, however, adopting the type of geometric formalism just outlined does manage to integrate the notions of situatedness, embodiment and speaker-hearer orientation, by taking, as its starting point, the speaker in a physical orientation to physical space as perceived and conceived by human beings.

2 Coordinate systems and vectors

2.1 Some formal systems in discourse analysis and cognitive linguistics

Since the aim of this paper is to outline a cognitive theory of discourse, let us consider briefly the matter of formal systems in discourse analysis and in cognitive linguistics.

(i) Possibly the most developed of discourse theories is the Discourse Representation Theory (DRT) of Kamp and Reyle (1993), a theory that has had some influence on the present approach. However, DRT does not claim to be cognitively motivated, although Kamp does occasionally maintain the cognitive *relevance* of DRT (cf. also Asher and Lascarides 2003: 376ff.). It is true that Kamp's project does resolve major problems, specifically anaphora, indefinite NP reference and definite NP reference, much debated in the logic-oriented tradition of twentieth-century philosophy. It is also true that in the more recent work, such as the SDRT (Segmented Discourse Representation Theory) of Asher and Lascarides (2003) and 'dynamic' versions of the theory (cf. Kamp, Genabith and Reyle (2005), DRT goes still further in explaining various phenomena of discourse coherence and context dependence. However, the DRT apparatus itself and its newer incarnations may be constrained by their predicate calculus foundations: in any event, they do not appear to systematically incorporate the concepts of situatedness or embodiment. DRT does not, for example, handle deixis in a naturalistic fashion, limiting deixis to objects in the non-linguistic context, similar to the way anaphoric referents are treated. For the essentially deictic concepts coded by linguistic tense, DRT also treats 'times' as referents more or less on a par with other discourse referents

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dimensionality because of their rootedness in the human cognition of physical space. Indeed, one could speculate that the origin of abstract linear algebra lies in the visual and kinaesthetic experience of space, an example of mathematics in the flesh not noted in Lakoff and Núñez (2000).

(‘yesterday’ has equivalent status to ‘Peter’ or ‘the donkey’), which seems counter-intuitive at least. In Discourse Space Theory, by contrast, it is assumed that temporal and spatial (and also modal) deixis are fundamental; consequently, the model integrates them into the representation of all utterances in discourse.

(ii) Set theory and functions, alongside predicate calculus, have been fundamental to formal semantics and pragmatics. Within cognitive linguistics itself, set theory and functions have been used in a somewhat different way. Mappings across cognitively defined sets of one kind and another are systematically used in mental space theory (Fauconnier 1994, 1997), in blending theory (Fauconnier and Turner 2002), and more informally in metaphor theory (Lakoff and Johnson 1980, 1999). The strength of the concept of mapping lies in its potential mathematical clarity, which enables it to model the phenomena of mental spaces that were first precisely identified by the authors just mentioned. As in the case of predicate logic, however, there is no inherent connection between sets-and-mappings and cognitive or linguistic processes that are situated and embodied. Specifically, they do not incorporate deictic phenomena. The DST approach sketched in the present paper owes much to the mental spaces approach, but re-casts mappings across spaces as coordinate correspondences on three fundamental dimensions.

(iii) The third type of notational, if not formal, apparatus, is essentially geometric, and is more closely tied to the tenets of CL, particularly to the idea that spatial cognition is somehow fundamental to linguistically coded concepts. Talmy’s detailed accounts have this geometric quality (for example the account of path concepts in Talmy 2001), as does Langacker’s consistent use of iconic pictorial diagrams (Langacker’s (1987, 1991, etc.). Langacker-diagrams, which are designed to capture a range of intuitions about linguistically encoded meanings (e.g. ‘foregrounding’, ‘prominence’, ‘trajector’, ‘distance’), can probably be transposed into standard geometrical concepts. For instance, Langacker-diagrams generally encapsulate topological relations, directionality, relative distance, scalar magnitude and geometrical projection. It is important that there is also a claim that the iconic diagrams capture *non*-linguistic perceptual or conceptual phenomena, with a particular emphasis on vision.

These three contrasting ways of representing discourse have their strengths and weaknesses. DRT representations are a powerful device for modelling many discourse relations, but they are not cognitively motivated (despite the way the embedded 'boxes' in typical DRT diagrams suggest Fauconnier-type mental spaces in certain cases). Langacker-diagrams hook onto spatial intuitions that are cognitively plausible but they are unwieldy and not productively manipulability in the way logico-mathematical systems are. The Discourse Space Theory outlined here, draws on insights and methods in these three approaches. It is a project that investigates the applicability of coordinate vector geometry for the representation of discourse processing, on the grounds that this formalism is systematic, well understood and, importantly, well motivated for the description of non-linguistic perception and cognition.

2.2 Coordinate systems and vectors: what comes for free

Geometry is an immense and rich field in mathematics, of which only a small corner is considered here (for the potential scope of geometry in many forms for cognitive linguistics and cognitive science, see Thom 1970, Petitot 1995, Gärdenfors 2000). Vectors viewed in their basic spatial form, are mathematical objects that have (a) magnitude (i.e. length) and (b) direction. They are often represented graphically as arrows, but can be interpreted as forces, translations (paths), functions, or sets of points on Cartesian axes. Both negative and zero vectors are defined. Standard operations on vectors that are of relevance in DST are addition, subtraction, scalar product.[2]

An important element in the theory of vectors is the concept of vector space--sets of vectors that can be represented in systems of coordinates of *n* dimensions and which satisfy certain axioms that we don't need to go into here. One of their advantages is that they can model physical processes and geometrical properties, but also quite abstract relations.

Linear transformations, which are mappings from one vector space into another, are a highly developed part of mathematics and its applications, and only some elementary cases seem relevant for present purposes. The transformations that are of interest for

[2] Standard mathematical definitions are taken for granted in this paper. Readers not familiar with vector algebra might refer to Anton (1991).

DST are the following: axis transformations, dilation and contraction transformations. *Axis transformation* refers to any function that shifts the position of a coordinate system to a different position with respect to itself. This is a concept that will prove to be of great use in investigating how to handle discourse viewpoint and mental spaces (in Fauconnier's sense) within DST.

Another class of transformations is of particular cognitive interest because they appear to correspond to some key insights developed by Langacker (1995). These are *dilation and contraction transformations*, which use a scaling factor to enlarge or reduce the magnitude (norm) of a vector.[3] Transformations of this type can be thought of as zooming-in and zooming-out, an operation that has a neurophysiological basis in the processing of proximal and distal stimuli,[4] as well as in various linguistic and discourse phenomena, for example the alternation between imperfective and perfective aspect, and what Langacker calls the 'viewing frame' (1995, cf. Langacker 1991: 44-444, 499-501,).[5]

3 Coordinate systems and vectors in language and language use

3.1 *Prepositions and viewpoint in physical 3-space*

It is possible to use vectors to define a purely truth conditional semantics for prepositions (as Zwarts 1997, 2003 and Zwarts and Winter 2000 have done), but O'Keefe's work is of particular interest because it is grounded in the modelling of the neurological correlates of spatial cognition in the mammalian hippocampus. According to O'Keefe, the firing of hippocampal 'place neurons' represent a probabilistic model of 'place regions', such that places are represented as concentric tear-shaped regions

[3] Dilation and contraction transformations are also known as 'similitude'.

[4] Among the neurophysiolical processes that give motivation for Langacker's rich visual metaphors (principally focus/scanning, fore-/background) are: the perceptual mechanisms of binocular vision, binocular scanning and focus, lens modification, retinal image size; the cognitive processes in the visual pathways that compute 'depth' and distance; processing in different brain areas of near (peripersonal) and far space (e.g. Weiss et al. 2000). Vector geometry serves well to describe many of these neurophysiological processes, as argued above; it is used in DST as a bridging tool to describe and explore conceptual effects i9n discourse produced by linguistic coding.

[5] In this connection, it is worth noting that the contraction transformation can be defined as reducing asymptotically to a point, or, alternatively, as a linear transformation that reduces actually to a point, that is 'loses' a dimension. It is worth noting further, the special case of the zero transformation, which maps a vector space into the origin. These considerations are of particular relevance in the investigation of the representation of tense, including the nature of the present tense, within the present framework, but developing them further is beyond the scope of the present article.

whose centre is located at the head of a vector whose tail has coordinates at the point of perceiving organism.

Figure 1: Prepositions as vectors (after O'Keefe 2003: 79)
ABOUT HERE

For example, O'Keefe defines the English preposition *behind* as the set of vectors **V** such that any member of **V** has its tail at the deictic origin, is greater in magnitude than a reference vector drawn from the origin to the object, and has an angle smaller than that between the reference vector **a** and the vector **b** tangential to the reference object (see Figure 1). In O'Keefe's account, the region is structured in such a way that there is a greater probability of finding the object to be located (corresponding to the NP complement of the preposition) at the centre of the region. Experimentally, if people are asked which points in space best satisfy the subspace denoted by *behind the box*, the acceptability rating is highest in the peaked central region.

Similar vector/region representations can be established for most of the other spatial prepositions, using a 3-dimension coordinate system. Prepositions pick out regions in all three dimensions of Euclidian space as perceived by humans.[6] The geometric intersection (origin) is equivalent to the deictic centre, i.e. the speaker of the current utterance in a discourse—and it is this that gives one aspect of speaker orientation, embodiment and situatedness. Human embodied cognition imposes orientation on the 3 axes, by coordinating the gravitational signal, the sagittal back-front axis and its orthogonal complements in the horizontal plane, i.e. the left-right axis. First-order predicate logic and propositional calculus cannot easily accommodate such things (as argued, for instance, by Landau 2003).

Figure 2: Egocentric representation of some spatial relations
ABOUT HERE

[6] Two important and quite well-known riders need to be added. First, not all prepositions utilise all three dimensions: English *at*, for instance, uses one, denoting a point, *across* uses two. Second, as argued by Herskovits (1986), for example, additional image-schematic concepts may be required for a complete description of prepositional concepts.

A number of English prepositions can be defined as vector spaces in the three planes with origin at the intersection representing either the speaker S or the landmark object (the latter being also located within the space whose origin is S). Some prepositions (e.g. *near*, *close by*, *far from*…) only specify a kind of scalar distance relative to the origin, while direction in terms of the 3-dimensional axes may be given in the discourse or situation. This approach provides the possibility of a more integrated approach to prepositional concepts than most current accounts, which tend to deal with prepositions piecemeal. However, this does not mean that the vector space approach claims that the entire semantics of prepositions can be so specified, since a full account seems to require a functional semantics as well (cf. Evans and Tyler 2004; Sinha and Jensen de Lopez 2000; Tyler and Evans 2003; Vandeloise 1989/1996; Zwarts 2003: 43).[7]

3.2 Egocentric and allocentric frames

What we have said so far assumes an egocentric and unitary set of axes, but it is well known that the human representations of space operate with multiple axes and can shift from one to the other.[8] In fact different brain areas appear to be responsible for the different spatial coordinate systems (cf. for example, Gallistel 1990, Andersen 1995, Burgess 2002).

In cognitive linguistics, shifting viewpoints are frequently mentioned and they are fundamental. It is also well known that language enables us to encode a shift from an egocentric speaker's viewpoint, to an allocentric viewpoint, i.e. there is a shift of deictic centre or geometric origin. Langacker (1995) and van Hoek (2003) go a long way in demonstrating the extent of such phenomena in language, using Langacker-style pictorial diagrams. The theoretical framework outlined in this paper fully acknowledges these accounts, while claiming that a geometric coordinate system provides the most natural formal apparatus. It is clear that in order to account for this area of linguistic meaning, which has an obvious 'embodied' motivation, some appropriate mechanism is

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[7] Note also that, although the prepositions *in(side)* and *out(side)* can be insightfully handled in geometric vectors, their semantic properties seem to be inherently topological. Some may involve a variety of geometrical relations, as well as non-geometrical ones (like support, which is a force dynamic relation): cf. Herskovits (p.c. cited in Gärdenfors 2000: 172-3). The issues are complex, but note that contiguity relations (cf. *on*) can be captured by a zero vector and that force is standardly modelled by vectors.

[8] Levinson (1996) considers the phenomenon cross-linguistically and has demonstrated also the existence of absolute (geophysical) frames of reference (e.g. in Tzeltal and Guugu Ymithirr), which are not treated in the present article.

needed. This is easy to do if we adopt coordinate systems our basis, since translation of axes, a standard operation, comes for free with the geometric framework. We might hazard the guess that the viewing organism is computing an analogous operation, and the linguistic coding of such shifts can be represented quite simply as vector spaces in alternate coordinate systems.[9] Familiar cases such as (1) can be handled in this way:

(1) John is in front of the church.

Since some buildings, in some cultures, have an orientation calqued on human orientation, (1) is ambiguous.

The cognitive alternation one experiences in (1) presumably corresponds to the switching from a coordinate system centred on the human speaker to one whose origin is positioned on the landmark object (the church) and whose axes are directed relative to it. What is the relation between the two coordinate systems? It seems that as far as cognitive discourse processing is concerned, this relation does not correspond to a transformation defined in a strict sense, since for that we would need to be able to specify a function that would map (i.e. translate and possibly rotate) a copy of the base space to a new location relative to the base space. In one of the interpretations of (1), the interpreter is not adopting a viewpoint located at the church; the base coordinate system (based on speaker's and interpreter's real-space location) is not actually shifted. This is the egocentric viewpoint, where ego is the speaker, S, who is oriented toward (i.e. is facing) the church and *John*'s position is between the oriented speaker and the church.[10] In the second interpretation of (1) *John* is located relative to the church's orientation—specifically, relative to the church's 'front'. This interpretation is an allocentric representation: the centre of the axis system is located at the distal church,

[9] I am concentrating here on the need for oriented axes, but note that in the vector theory of prepositional meaning (O'Keefe 1996; Zwarts 1997) the meaning of a preposition P is given by a vector space consisting of vector emanating from a an origin at the reference object . This means that if an entity has a position vector that is a member of that space its relation to the reference object can be denoted by P. However, O'Keefe's (2003) approach makes certain positions in the space more probable meanings for P—more 'prototypical'. This means that O'Keefe's model, with its biological and mathematical grounding, is a more detailed equivalent of Tyler's and Evans's (2003) notion of 'protoscene' for spatial prepositions, since their pictograms indicate a 'proto' position for the trajectory with respect to the landmark.

[10] The 'in front' of relation in this sense can be defined more precisely as the set of vectors **V** that includes all vectors with origin at S within an angle defined by relative to the vector from S to the landmark object, the church.

not at the speaker. In the straightforward case, the church itself is located by a vector whose tail is at the origin, S, and a shift of S's base system is defined (by translation and possibly rotation of axes). However, in many real situations, no such vector can be computed. For instance, one may say 'Go into the piazza; the statue is in front of the church', without either speaker or interpreter needing to calculate the orientation and distance of the church's coordinate system with respect to their own. Nonetheless, a shift to an allocentric representation is clearly involved in such an example. The point remains that egocentric and allocentric spatial coordinate systems are a natural part of the human cognitive equipment and that linguistic expressions cue one or the other depending on contextual factors in the real world of discourse processing. In any event, we should not be limited by the single example of (1). In point of fact, spatial viewpoint shifts obviously are constructed in discourse:

(2) Go to the end of the bridge: the church is in front of you.

We might imagine something like the following cognitive operations occur during processing of (2). (i)The hearer, H, can locate the bridge in his own mental representation of physical space (egocentric representation). (ii) To understand *to the end of the bridge*, he then has to initiate an allocentric representation in which *the end of* is defined relative to the bridge, such that the bridge is aligned with a path that has a beginning and end, i.e. a vector whose tail is at the start of the bridge. Note that this arrangement will not be entirely allocentric, since which end of the bridge is selected as the starting point depends on the way the bridge is positioned in the egocentric space represented in (i). Then, (iii), H has to decide the interpretation of *the church is in front of you*. The hearer has now mentally shifted his own (egocentric) axes to the end of the bridge, indeed has aligned his sagittal axis with the structural axis of the bridge itself and the location of the church is given by *in front of* interpreted relative to the egocentric axis system of H. Presumably, then, understanding (2) requires several representations involving axis shift, and these representations are not only sequential but nested.

The point of these examples is to show how discourse seems to trigger axis shifts from egocentric to allocentric representations of physical space. But shifts of 'viewpoint' occur also in the domain of abstract discourse processing, as Fillmore, Langacker, Talmy and others have amply demonstrated. What the following sections aim to do is to show how a projection of these mechanisms may underlie key aspects of discourse processing at the more abstract level that linguistic forms appear to prompt.

4 The abstract discourse space

In his description the properties of the nervous system Gallistel (1990: 475) notes that 'the aspects of reality—space, time, probability—[…] lend themselves to vector representation'. Interpreting vectors in the geometric sense, one may come to a similar conclusion for the representation of the fundamental structure of discourse processing. The starting point for DST is the hypothesis that we can represent some important elements of discourse by means of a Cartesian coordinate system. Presumably actual processing of discourse involves processing in a large number of conceptual domains with their own dimensionality (cf. the approach to properties of entities outlined in Gärdenfors 2000), including the three-dimensional physical domain, which is the one discussed in the previous section. However, discourse meanings are only partly concerned with the conceptualisation of physical Euclidean space. Any attempt to model discourse conceptualisation, that is the conceptualisations produced during discourse processing, need to attend to what is specific to that process. The process involves an interaction between a situated speaker and a situated hearer (or their analogues in signed or graphic form): for simplification we focus on the speaker. Being situated can be understood in terms of 'viewpoint' and the latter can be understood in terms of space, time and epistemological stance. The claim is thus that what is specific to discourse conceptualisation is the integrated representation of the speaker's consciousness of his/her own (literal) position in space. This is not of course objective 'position in space', but cognitive position in space as constructed in the mind of the speaker. The same is true, *mutatis mutandis*, for the 'position' in time. With regard to epistemological stance, the claim here is that any speaker or hearer processing discourse not only positions him or herself in space and time, but also in the 'space' which, from his or her viewpoint characterises what is true, less true, not true. In general we refer to the epistemological space as modality, and include deontic as well as epistemic cognitions. DST is triply deictic in this sense.

4.1 s-axis

The s-axis, is termed spatial, and corresponds to a scale of relative distance from the deictic origin. However, the s-axis is actually an abstraction of spatial representation that reduces the three Euclidean dimensions (though of course it assumes that these are also processed in discourse, as indicated in section 4.2 In the model the s-axis thus minimally preserves direction and magnitude (distance). There is no objective metric for locations on this continuum (e.g. *this book* vs. *that book*) are not precisely measurable: the relevant metric is relative and scalar.

Events in the discourse space are relatively proximal to or distal from the speaker, or from some reference point that is also relatively close to or remote from the speaker. Further, events are directed towards or away from the speaker at the origin or towards or away from a reference point. The instances, and indeed the directionality, are in the conceptualisation not necessarily in the objective world. We might consider several kinds of distance along the s-scale.

Figure 3: Relative distance from 0 on spatial axis
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(a) The fundamental distance can be defined in terms of peripersonal space, the extent of which we can take as a unit vector in the discourse space (on peripersonal space, cf. Gallese 2003, Weiss et al. 2000). It is also the distance that we can take to be the spatial component for transitive verbs in English such as *touch*, hit, *grasp*, *hold*, *knock*, *kick*, *break*. This approach provides a basis for representing action verbs as vectors (see Figure 3).

(b) Action verbs are directed: intransitive motion verbs co-occur with a conceptualisation of source and goal (even if these are not overtly expressed). The vectors representing them can be interpreted as translation vectors. Transitive action verbs are directed in the sense that an effector (hand, hand-held instrument, etc.) move away from the body within peripersonal space towards a goal. Vectors representing them can also be interpreted in terms of force. It follows that the initial point of the vector can be interpreted as corresponding to the agent participant role, the terminal point to the patient or goal role.

(c) The location of the initial and points on s can be relatively close to or relatively distant from the 0 (speaker). That is, the head of the vector can be closer to 0 than its tail. This corresponds to the process whereby a patient or goal is more prominent from 0's viewpoint than the agent—a type of cognition encoded in the passive construction.

(d) What is said in (c) also corresponds to the perceptual-cognitive distinction between figure and ground, where figure is cognised as closer. This is needed for well-known cases like *the plant is by the house vs ?the house is by the plant*, and may be extended to the more abstract discourse relation of topic and comment.

(e) It is possible that the s-axis should be extended for more obviously metaphorical cases of 'distance' that appear to have a fundamental importance for situated human cognisers. For example, certain kinds of conceptual distance correspond to social 'distance'; for some speaker or speakers, some location might be evaluatively 'distant' or even 'alien', irrespective of physical, or geographic, distance.

4.2 t-axis

As shown in Figure 4, the s-axis 'rotates' metaphorically onto the temporal axis (*t*) — which gives us relative temporal 'distance' from the origin in two directions, past (-*t*) and future *(+t*), both on scales of 'distance' relative to time of utterance. The suggestion here is that the space-time plane in human discourse space involves a temporal dimension that is conceptualised by analogy to spatial distance and direction, as indicated by linguistic expressions: the time-as-space metaphor is well known.

The formalism is based on the widely observed spatial metaphor for time, which, incidentally, seem to be reducible to distance and direction metaphors, without reference to the 3-dimensional back-front, side-to-side, and up-down dimensions. The t-axis is not 'time's arrow' as represented conventionally (e.g. in space-time graphs),[11]

[11] Time can be represented as moving in one direction, however, in 'time is a moving object' metaphors.

but directed according to the speaker's (0's) viewpoint: events can be relative 'close' or relatively distant' in the past, and similarly for the future. The two opposed directions are conventionally labelled *–t* and *+t*. In English these directions correspond to a systematic front-back orientation found in expressions such as *look back to the past* vs. *look forward to the future*, which are derived from a specific aspect of human embodiment. However, the precise plane of orientation in human 3-space is not relevant. Some languages, for instance, appear to have up-down rather front-back metaphors for where time goes to and comes from (e.g. Mandarin, cf. Yu 1998, Radden 2004). What is relevant in all conceptual spatialisations of time is bi-directionality and distance.

Figure **4 Spatial distance metaphorically projects onto temporal distance ABOUT HERE**

The DST framework also suggests that there could be a temporal 'near' space corresponding in some way to spatial peripersonal space, perhaps by way of embodied experience of diurnal cycles. Like other 'locations' in the discourse space, events can be viewed egocentrically or allocentrically, that is, taking 0 as reference point or some other event relatively distal to 0 as reference point. The conceptual structure of time vectors thus inherits, or abstracts from some of the conceptual properties of spatial vectors.

4.3 m-axis

The third axis is the modal axis (m), and its role is to reflect what seems to be the case for all utterances, namely that speakers entertain meta-representations and give them a valuation in terms of their subjective truth value.[12] States of affairs are always certainly true relative to the speaker, possibly true, certainly not true. Can modality in this sense be modelled in terms of spatial concepts? That it can be is implicit in observations made by several linguists. Langacker, for instance, talks of modality in a way that almost (but not quite) formally defines a vector:

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[12] This paper concentrates on epistemic modality; the incorporation of deontic modal expressions into DSMs requires detailed investigation.

[...] the modals can be described as contrasting with one another because they situate the process at varying distances from the speaker's position at immediate known reality. (Langacker 1991: 246)

Frawley (1992: 384-436), drawing in part on Chung and Timberlake (1985), outlines a deictic theory of modality that also has distance and direction as intrinsic features in direct correspondence with spatial deixis and the spatialised deixis of time. To add substance to the implicit vector-based characterisation of modality, we need evidence of a scale of some kind. As a working hypothesis, the modal axis in the discourse space model refers to a scale based on an intuitive grading of the English modal adverbs, adjectives and auxiliaries (cf. Werth 1999: 314-5).

is,	necessary,	probable,	possible,	uncertain,	improbable,	impossible,	is not
	must be,	should be,	might, may	might not, may not,		can't be	

There are complexities in the linguistic expressions that are not relevant to the argument here. If such a scale is adopted, a consequence is that the negation end is maximally distal from the speaker at 0. The terms *realis* and *irrealis* refer, respectively, to proximal modal space that corresponds to what is most real for the speaker and to maximally distal modal space that corresponds to what is most unreal for the speaker, where 'most unreal' is understood as equivalent to what is expressed linguistically through negative particles and the like.[13] Another feature of the scale, that it is possible to assume a mid-point, is suggested by two kinds of linguistic evidence. The first is that a sentence such as those in (3) are not self contradictory, whereas those in (4) are:

(3) (a) John might go to the party and/but he might not go
(b) Possibly John will go to the party and possibly he won't
(4) (a) *John must have gone to the party and John must not have gone to the party
(b) *Probably John went to the party and probably he didn't.

[13] Negation and its representation is a complex matter that cannot be dealt with here. It is generally pointed out, for instance, that negative sentences in some cases presuppose a positive assertion in the discourse space. The DST model can accommodate two such representations in a natural way: the presupposed factual assertion has coordinate m=0, the counterfactual (negated) proposition is located at maximal distance from 0 on m.

The second kind of evidence, the existence of modal ‘Horn-scales’ (see Horn 1989, Israel 2004) also suggests symmetry. While the scale above is a unidirectional conceptual gradient from *realis* to *irrealis*, the semantic entailment relations in each half of the scale are mirror images of one another. For example:

necessary(x) > likely(x) > possible(x) uncertain(x) < unlikely(x) < impossible(x)

A number of issues remain to be resolved. One is the question of deontic modal expressions. As is well known languages frequently use the same or overlapping ranges of expressions for both epistemic and deontic concepts (Sweetser 1990). I do not attempt to pursue this here, except to note that in English and other languages there exist idiomatic polysemes that use spatial distance and direction metaphors for concepts of normativity: e.g. *John has gone too far this time*, *it is beyond the bounds of acceptability*, *her conduct is beyond the pale*, *it is outside the law*. The second issues concerns the persuasive and widely accepted theory that modal meanings are motivated by force dynamic conceptions (Talmy 1988, Sweetser 1990). In principle, since vectors can be interpreted as forces, and commonly are, there may be no formal incongruity, although the compatibility of the two theoretical approaches remains to be tested. On this evidence, which admittedly needs further research and fleshing out, DST proposes that the spatial axis also projects a modal dimension, as shown in Figure 5.

Figure 5: Spatial distance metaphorically projects onto modal distance
ABOUT HERE

The intersection of the axes, the origin, defines the viewpoint of the speaker S. On each of the three axes we postulate components corresponding to peripersonal space, and define them as unit vectors. The coordinate system described in this way corresponds to the speaker's self, in the sense that it corresponds to the speaker’s cognisance of what is *here* (the graspable in primary peripersonal space defined physically), what is *now* (what is temporally within reach, that is, peripersonal space projected onto time) and what is *real* (what can be ‘grasped’ cognitively and in some possibly non-linear fashion correlating with spatial and temporal distance). What this definition of a proximal spatio-temporal-modal space encapsulates is the intuition, reflected in language and discourse structure, that things are more likely to be real (and 'right'), for the speaker in the here and now. What is distal, either visually, or temporally, is less actual.

5 Viewpoint alternation in discourse space: transformation of coordinates

Having set up the axes of an abstract discourse space,[14] the model now proposes that certain fundamental aspects of linguistically encoded conceptions can be represented in the space in terms of

-- points or regions corresponding to entities (discourse referents)
-- movements of the points (entities), which may have a metaphorical interpretation (i.e. have meanings other than purely spatial ones)
-- relations between the entities (points)
-- relative distance from 0.

The coordinates of the points give us the basis for talking about the discourse space in terms of vectors. The mathematical object geometrical 'vector' is interpreted in various ways in various fields that seek to model (engineering, physics, navigation and cognitive neuroscience). Vectors can model relations, translations and forces. At least these three are applicable in a cognitive theory of human discourse representation, with perhaps other specific variations that will emerge from further research. The following sections discuss some cases where this approach appears to be fruitful.

5.1 s-axis: spatial relations, egocentric and allocentric

5.1.1 spatial relationships and discourse distance

Consider first how (1) and (2), discussed in section 3.2, appear in the abstract discourse space. The discourse space model (henceforth DSM, denoting a particular representation of a linguistic conceptualisation in the abstract discourse space coordinate system) does not attempt to represent spatial cognitions arising from linguistic expressions 3-dimensionally; this is not to say that in real processing, the

[14] Mathematically we would expect the coordinate system described here to constitute a vector space, given an adequate interpretation of vectors for discourse expressions; I do not attempt to demonstrate this formally here.

human mind does not does do so. The point of the particular three dimension of the model is explore specifically the interaction of spatial, temporal and modal conceptualisations. The representation of spatial relations in the DSM is at most 1-dimensional (points and lines). However, this still enables us to capture key discourse phenomena, including egocentric-allocentric switch and axis shift. The possible conceptualisations stimulated by (1) are diagrammed in Figure 6.

Figure 6 (i): Egocentric interpretation of (1) (ii): Allocentric interpretation of (1) ABOUT HERE

In Figure 6 (i) the arrow represents one vector specifying a spatial relation between the Speaker S and the reference object; John's position, as coded by way by his position of in *front of*, is given by his coordinates relative to this vector.[15] In Figure 6 (ii) John's position is given relative to a reference object other than the Speaker at 0. The DSM does not of course contain all the information needed for a full spatial conceptualisation, since it does not represent the three spatial dimensions. Bus as already noted, conceptualisation involves many parallel systems, one of which is the three dimensional spatial system of representation. What the DSM does is include specifically *discourse* relations

Let us consider a case where the s-axis is used for abstract distance that arises in discourse rather than in objective physical space. The sentences (5a) and (5b) are denotationally equivalent, but have different conceptual significance.

(5a) The pub is opposite the post office
(5b) The post office is opposite the pub

Loosely, we can say that in (5a) *the pub* is foregrounded, while in (5b) *the post office* is foregrounded. Because the s-axis stands for relative closeness to Speaker, and because vectors give us directionality, we can represent discourse foregrounding phenomena (trajector and landmark, figure-ground) by positioning one referent closer to 0 on the s-

[15] Actually, the vector stands for a set of vectors denoting the PP *in front of* (cf. O'Keefe 1996, Zwarts 1997). Note also that it might be necessary to specify a distance between *John* and the *church* to satisfy *in front of*.

axis than another referent. In vision the ground is what appears relatively more distant (backgrounded) in space. In the abstract DSM these phenomena are of course *quasi*-spatial (or *metaphorically* spatial): and constitute what might be called ‘discourse distance’. The DSM diagrams handle this very simply by changing the relative positions of the referents: in (5a), for example, *the pub* is ‘closer’ (more foregrounded) than the post office and the reference object is the *post office* more ‘distant’ (more backgrounded). The tail of the position vector is at *the post office* and its head at *the pub*. The case is reversed for (5b).

This section outlines how the DSM uses the s-axis to model both conceptualisations of (reduced) physical space and also indicates how the model gives rise to the notion of ‘discourse distance’. The most obvious use of such a notion is to integrate foreground-background construals into the geometric modelling of discourse. It is assumed also that ‘the linear ordering of NPs in clauses will be reflected in the ordering of referents on the s-axis. In the DSMs in this paper the subject NP of a declarative clause will be treated as ‘closer’ to S than an object NP, for example. We have seen that vectors can be used to represent the relation of objects to landmarks in 3-dimensional space. In DST they are also treated as representing the direction of activity from a source to a goal. In terms of thematic roles, this means that the tail of the vector might, for example, be located at the coordinates of an agent, the head at the coordinates of a patient. Of course, since the vector is directional, the orientation can be varied in combination with the relatively proximal or relative distal location of the referents with respect to S. This in turn means that it is possible to model the conceptualisations associated with passive-active constructions, raising constructions, and similar constructions in a unified and natural way.

5.1.2 s-axis: verbs of movement t and vectors as translations

For sentences denoting change of location such as (6), it is a simple matter to use vectors, understood as translation vectors (interpreted as a function that maps a point P to a point Q), as suggested in Figure 7:

(6) John went to Geneva

Figure 7 *go* as translation vector
ABOUT HERE

Here *John* and *Geneva* are in the Speaker's (S's) discourse space at time of utterance. *John* is relative 'close' to S in discourse terms (cf. Langacker's 'trajector'). *Geneva* is relatively distal ('landmark). In addition, physical spatial dimensions are relevant to the full ongoing cognitive representation. That is to say, *John* is known to S to be at some location at a certain location at a certain time and to be at *Geneva* at a later time, in S's geographical representation of the world. S's knowledge here is background knowledge and/or inference from the sentence (6). Though real world knowledge requires a representation of some time t_i earlier than another time t_j, the discourse representation, motivated by linguistic expressions, implies a punctual event because of the past tense form *went*. The vector in Figure 7 is interpreted as a translation vector changing the coordinates of the discourse referent *John*.

All verbs of movement encode conceptualisations corresponding to translation vectors. It is also quite natural in the discourse space to deal with deictic verbs like *come*/*go, take/bring* in their apparently non-deictic uses, since the facility for translation of axes to an allocentric viewpoint comes with the formalism. This enables us to deal with cases like:

(7) Mary waited at home. John came to the house

Figure 8 Deictic verb and translation of axes
ABOUT HERE

Figure 8 represents a particular interpretation of the second sentence in (7)—one which assumes that *home* refers to Mary's home, that the *house* is an anaphor whose antecedent is *home* and that this location is not John's home and is distal to S. This is the location to which moves. Alternatively, (7) can yield a representation in which S and Mary are in the same house at s=0, S is located there and John translates himself to s=0. The latter case uses the base egocentric coordinates; the former shifts the axis system in order to establish an allocentric viewpoint. The DSM enables us to show the translation of axes for the allocentric reading. Suppose now that the verb in (7) was *went* rather than *came*. In this case, the appropriate representation in the DSM seems to be one in which there is not translation of axes to Mary's location.

5.1.3 s-axis: force vectors and causative verbs

So far we have interpreted geometric vectors as spatial translations. However, vectors are applied in many domains to stand for force. It is proposed here to extend this idea to the concept of cause encoded in linguistic expressions, although there are questions to be pursued concerning the relationship between force and cause. Componential semantics simply labels the concept in question as CAUSE. To treat this concept as a vector has the advantage of relating it to a principled system for the description of physical phenomena. As a beginning, consider (8):

(8) John moved the vase from the table to the shelf

The conceptual structure of this sentence seems to involve (a) a translation vector for *the vase*, (b) two locations for the vase that can be represented by a zero vector, and (c) a vector that may be interpreted as a direction of applied force, as suggested in Figure 9.

Figure 9 Translation and force
ABOUT HERE

Here we have *John*, *table*, *vase, shelf* as discourse referents already in the discourse space (indicated in part by the definite articles). These entities remain in the Speaker's reality space (m=0) at t=0. At time t_i before utterance time t_0 John applies force to the vase and the vase is translated to the shelf. There is an available inference that at some period of time before t_i the vase was located on the table and that at some point in time later than t_i up to and including t_0 the vase is on the shelf. The DSM diagram can show this, but does not do so here. Again, the tense form denotes a punctual event (though objectively, of course, the event is extended in time). What Figure 9 shows is that verbs such as *move* can be explained in terms of component vectors.

Beyond the cases considered so far, we would want to consider the range of predicates that appear to have spatially derived semantics, as in the case of possession as location, transfer of possession verbs, transmission verbs (saying, etc.) and perception and cognition verbs (cf. ‘he looked at/towards/in the direction of Jane’). In general it is possible to represent by means positional vectors in the discourse space the relations among discourse referents, as well as states. However, DST does not attempt to represent specific semantic properties of the relations and states (e.g. the distinctions between *went*, *travelled*, *journeyed*, *rode*, *drove*, *flew*, etc.) or other types of properties. As stated at the outset, the main aim of DST is give an account of embodied situatedness.

5.2 t-axis: tense transformations

The following analyses, like those of a number of other scholars, builds on Reichenbach’s (1947: 287-298) framework and uses insights from Langacker (1991, 1995). Description of English tenses require time points: the point of speech, event point and reference point (Reichenbach 1947: 287-8), with reference point often being defined in the discourse or pragmatically rather than explicitly in the sentence. The English tenses appear to correspond to different alignments of the three points. In DST the speech point is intrinsic in the discourse space. It follows Reichenbach in treating the three points in terms of relationships and ordering on the time-line. However, because the vector space includes direction as well as distance, DST says more about the nature of the relationships, and in particular it is able to incorporate ‘viewpoint’ (cf. Langacker’s 1995, Michaelis 1998, amongst others). It is able to do this by the use of vector spaces and by the axis shift operation.

5.2.1 Present perfect

The present perfect is associated with complex meanings (cf. Michaelis 1998 and Michaelis in press), and the present account seeks merely to indicate how certain key features can be handled in the deictic framework that is the essence of DST. The main features of the present perfect that have been described a number of writers are approximately the following. As distinct from simple past (reference point and event point simultaneous), the English present perfect represents an event in the past which is ‘referred to a point simultaneous with the point of speech’ (Reichenbach 1947: 289). Cognitive linguists have explored further the nature of this past-present relationship. Langacker describes it as ‘current relevance’ (Langacker 1991: 211), where a currently relevant phenomenon may be, for instance, a state resulting from a past event that endures up to (and into) the utterance time. Michaelis's (1998) account, focuses on several meanings of the present perfect: speaker's view or construal of an event, the endpoints of an event, and 'a state of "aftermath" following the culmination of an event' (*ibid*. p.10). Like the present account, these cognitive accounts are speaker-based.

A model of the present perfect has to refer to both the initial or initiating point of an action and to the end (or result) point, the relationship of an event's initiation to the present, and the relationship of the event's result to the present. The initiator of an event is related to the whole event, including the initial and the result point. A model will also have to give an account of the contributions of the auxiliary *have*. The task here is to outline the way in which DST is able to accommodate these several facets of meaning in virtue of its exploitation of vectors and their standard properties. We will (over-)simplify the issue by concentrating on a simple example:

(9) Mary has broken the vase.

Adopting the position that all morphemes in the construction have cognitive significance, we can treat *have* as literally a possessive, and cognitively as a spatial[16] relation that can be represented by a vector, as shown in Figure 10.

Figure 10 Present perfect
ABOUT HERE

The auxiliary *have* can be shown as a negative vector, pointing toward the past, on the t-axis, and having its tail at t=0 and m=0, i.e. the point which, for S, is the present and is modally *realis*. On the s-axis its tail is at the coordinate for *Mary*, the performer of the past action, but this still anchors Mary's past action to the Speaker's own present, the time of speaking. What the *has* vector does is locate the event (*break*) in the recent past,

[16] This point is made also by Langacker (1991: 212), who views possession as a 'reference point relationship' (*id.* 1991: 167ff, 1995: 191). For Langacker, the auxiliary *hav*e in the present perfect derives from a spatial function denoting spatial proximity: 'a spatial reference point becomes a reference point in time…' (*id.* 1991: 214). Although the DSM space is an abstract discourse space, vectors in it are spatial in the sense that they are derived ultimately from spatial cognition. The vector representation is a formalisation of the locationist account of possession (cf. Anderson. 1971).

i.e. proximal relative to other events in the discourse, the precise location on t being left open here.

The action itself, the breaking of the vase, begins at the same coordinate on the s-axis as that for the beginning of the *has* vector. This past action is represented as a punctual event, having no temporal extension, relating the agent and the object. By standard vector addition of the *have* and the *break* vectors, we automatically get a vector (dashed arrow) from *Mary* to the end point of the action vector. This can be understood as relating the initiator (*Mary*) to the completion of the action -- a useful result, since many commentators have noted that the meaning of the English present perfect includes completion of an action brought about by an agent. Mary is the agent of both the initiation and the completion.

We also want to show that the completed action has consequences ('current relevance') for the present, that is, the current speech points (i.e. the origin of S's coordinate system). The DSM captures this by adding a reverse vector (second dashed arrow), parallel to *have*, from the end of the action up to the present. The *has* vector is negative because it is oriented to the past (the –t half line); the parallel vector is positive because it is oriented towards future. This can be thought of a as an iconic representation of the meaning of the present perfect, which, as noted above can combine both anchoring of past in present and implication of present (and indeed future) state of affairs. But it may be more than a merely iconic pictogram, since spatial representation of time relations and vector representation of space may be an inherent characteristic of the human cognitive apparatus.

5.2.2 Past perfect

If we turn to the past perfect, similar principles apply: it is the dual structure of the perfect tenses that is crucial. That is, in order to conceptualise a sentence like

(10) Mary had broken the vase by the time the boss arrived,

we need two positions in the coordinate system, one relative to the utterance time and one relative to some other past event.

While *has* is a locating vector that starts at zero, the past tense form *had* is a locating vector that starts at some past point on the t-axis—in Reichenbach's terms at another reference point. How do we characterize this reference point in DST? The DST proposal (see Figure 11) is that we have a translation of axes, related to the type we have seen for spatial prepositions, a viewpoint alternation for which the brain may be hard-wired. In geometric terms there is a translation from one set of axes to another in the space-time plane. In this case, *had* starts at a point in the past denoted by the expression *by the time the boss arrived*, so we place the origin of the new system of axes at this point. The new system is still, however, in Speaker's *realis* plane (m=0) and the viewpoint is still that of the Speaker (although there is also a free-indirect-style interpretation of the sentence that would shift the axis to Mary's coordinate on the s-axis).[17]

Figure 11 Past perfect
ABOUT HERE

Without going into details, which are a little more complicated, we can see that axis shift (see Figure 12) can also be used to represent the conceptualisation of the future perfect in a sentence like

(11) Mary will have broken the vase by the time the boss arrives.

Figure 12 Future perfect
ABOUT HERE

5.3 m-axis: reality transformations

5.3.1 Basic modalisation

DST regards modalisation, in a broad sense, as integral to all utterances and their interpretations. To see how DST handles a simple case consider the modalised version of sentence (8):

[17] As will be seen below, certain constructions (e.g. *if*, *wish that*, etc.) combine with the relatively distal position on t to give a maximally distal position, i.e. counterfactual, position on m.

(12) John might have moved the vase from the table to the shelf.

The modal axis of the DSM makes it possible to represent such simple cases by shifting the coordinate system, along with the vectors for (8), so that the origin is now at a point on the *m*-axis. Of course, there is the question as to which *is* the relevant point on the m-scale, and the provisional answer for this adopted in this article is that it is the epistemic *mid-point* between subjective certainty and counter factuality (cf. section 4.3 above).

In the DSM for (8), *John*, *the vase*, *the table* and *the shelf* are all in the reality plane (i.e. with m=0), as far as the Speaker is concerned; and the location of the vase on the table is also real and true for the Speaker up to a certain time t in the past. (Again, the two inferred states prior to and after the event are not shown, though they could be.) It is only the *relations* between entities after this time that are shifted to the modal coordinate corresponding to a mental space of what is possible (might be or might not be the case), from the point of view of the S at the deictic origin. One of the things that a DST model is able to do is separate out the participants in events from the relations among them, into different subspaces of the discourse space, e.g. into possible or imagined subspace.

5.3.2 Complementising predicates as coordinate shifters

This section is concerned with the complentising predicates that take *that*-clauses. A subtle survey of several types of complentisers is given by Langacker 1991, whose visually based diagrams provide many analogues with the DST approach. However, Langacker does not investigate sub-classes of *that*-clause verbs. In fact, there seem to be cognitively significant differences among conceptualisations triggered in discourse by the different verbs of this type.

Verbs taking *that* as complentiser have properties that can be modelled directly and naturally in DST. As has been widely observed, the class of complementising verbs are predominantly ‘psychological’, or more appropriately cognitive. Within the class they seem to form subgroups along two (at least) variables: type of cognitive state denoted by the semantics of the verb (*know*, *guess*, *imagine* …), and presence or absence of the ability to trigger existential presuppositions. For present purposes we will focus on the distinction between factive and non-factive classes of *that*-verbs. Using the usual negation test for presupposition, (13) does not trigger a presupposition, or in cognitive terms, a proposition judged true, real or known by the situated speaker, while (14) does trigger a presupposition in that sense:

(13) John (believes, thinks, imagines, holds, claims, argues, reasons, deduces, concludes, hopes, fears, suspects …) that Mary wrote the report.

The list in parentheses predominantly includes verbs that denote 'epistemic' states and some that denote more affective ones; semantic structure of this set is of potential interest but will not be explored here.[18]

The class of factive verbs, i.e. presupposition triggers, is well recognised and much debated in the pragmatics and semantics literature:

(14) John (knows, realises, recognises, sees, admits …) that Mary wrote the report.

Broadly speaking, the class of non-presupposition triggers seems to be predominantly affective, the class of presupposition predominantly or exclusively epistemic. Finally, there is a class of verbs whose semantics make the complement clause refer to future events or states; the common meanings of these verbs is broadly directive or deontic in character and involves the English quasi-subjunctive:

(15) John (requires, demands, stipulates, insists…) that Mary pay(s) the full price.

The point here is that in order to characterise the semantics of these verbs, or to characterise the constructions whose heads they are, the effects displayed in the different class types (13), (14) and (15), should be taken into account, since they are not attributable to pragmatic context but to the conventional meaning associated with the morpheme. The DSM can model these distinctions in a natural way, with respect to both 'distance' effects and to the way in which the *that*-clause relates to the Speaker's reality.

[18] There are many adjectival predicates that take *that*-clauses (e.g. *be surprised*, *shocked*, *horrified*, *appalled*, *pleased*, *delighted*…). Interestingly this set is factive. There is a large set of affect verbs that are factive with the complementiser *the fact that*.

Relationships we want to model are represented by coordinates, points, vectors and translated axes in Figures 13, 14 and 15. To illustrate how the DSM works, we consider also modalised variants of (13) and (14), given in the (b) examples below:

(16a) John (knows, realises, recognises, sees, admits …) that Mary wrote the report
(16b) John knows that Mary might have written the report
(17a) John (believes, thinks, imagines, holds, claims, argues, reasons, deduces, concludes, hopes, fears, suspects …) that Mary wrote the report.
(17b) John believes that Mary might have written the report.

FIGURE 13 *Realis* clause, complement of *know*
ABOUT HERE

In Figure 13 there are three discourse referents, *John*, *Mary*, *the report* and they are all in the reality plane (m=0) for the speaker S. They have relative discourse distances (as outlined in 6.1.1) from S. The complentising verb *know* asserts that S knows (considers real) a certain mental state of John's. The content of this mental state, as far as (16a) is concerned is the same as S's, viz. the event of Mary's writing a report. The event is related to both S and (according to the sentence) John by the same distances on t and on m. But the proposition 'Mary wrote the report' is, none the less, given the semantics of the sentence, related specifically to John as well as to S. We can show this if we treat *know that* as a transformation that translates an image of S's coordinates to the discourse space position occupied by *John*. The semantics of *know*, because of its intrinsic presupposing properties, has the modal position (real, i.e. m=0) identical for both S and the discourse referent *John*. Note that the only difference is the magnitude of the vector from 0' to the representation of the event compared with that for 0. This is at it should be: as noted e.g. by Langacker (1991: 447), complentisers give the embedded process greater 'conceptual distance' ('objectify' it).

The case of (16b) shows that transformed axes are necessary if we want to capture other possible conceptual elements that can occur inside a *that*-clause, here modalisation. (16b) presupposes *Mary might have written the report*, i.e. that this event is in S's reality plane. Figure 14 shows how the transformed axis system works. The position of the event is the same as before but the position on m axis is at its mid-point, let us say for the sake of argument (cf. above section 4.3). Again, as in (16a), the coordinate systems of S and of the discourse referent *John* coincide, except for the position on the s-axis.

Figure 14 Effect of modal *might* in clause complementing *know*
ABOUT HERE

Turning to (17a) and (17b), the effects of the semantics of *believe* is that no presupposition appears in the interpretation. That is to say, the embedded proposition does not appear in the mental representations that constitute S's reality plane. We can, again for the sake of argument, assume that for S the embedded proposition is epistemically undecidable in either direction, as suggested for instance by (18):

(18a) John believes that Mary wrote the report and possibly she did, possibly she didn't.
(18b) ?John believes that Mary wrote the report and probably she did
(18c) ?John believes that Mary wrote the report and probably she didn't.

Returning to (17a), the interpretation seems to be that S's sentence means, inter alia, that the event is real for *John* but not real for S. Figure 15 shows how axis shift again captures conceptualisations of this kind.

FIGURE 15 Believe as coordinate shift on *m*-axis
ABOUT HERE

The expression *believe that* is treated here a transformation function, different from the one used in the case of (16) in that its image has a different *m* value (m_k, instead of m_0). The coordinates of the discourse referents are the same for both S (speaker) and for the referent *John*. The time coordinate for the event is t_k for both S and *John*. The effect of this transformation, however, is to separate *John*'s reality plane from S's. What is reality for John coincides not with m_0 on the base coordinate system but with (we have supposed) m_k in that system. As for (171b) we can consider the effect of a modal expression in the embedded clause. Figure 16 illustrates this. The effect on S's *m*-axis is to create even greater 'conceptual distance' than in Figure 15 -- by shifting the content of *John*'s belief more towards the distal and counterfactual end of S's *m*-axis. Intuitively, this appears to be appropriate.

Figure 16 Effect of modal in *believe* complement clause
ABOUT HERE

In one sense we are not dealing here with 'presuppositions'. In the mainstream literature 'presuppositions' are defined truth conditionally, whereas what we have given above is a cognitive account, in which the 'presupposed' proposition remains a conceptual construct (in the mind of S). It is, however, compatible with Fauconnier's (1994) mental space approach. Note that in the case of (17a) and (17b) we could say, within the cognitive perspective developed here, that in fact there *is* a 'presupposition', in the sense an interpreter of the sentence will attribute to S that S has a judgement of the epistemic value of the embedded clause ('the event may have happened it may not'). The cognitive approach thus leads considerable way from the analysis that holds that *believe* type predicates do not presuppose.

Langacker's (1991: 438-463) overview of complementisers places various types (*that*, *to*, *-ing*, zero) on a scale of 'objectivity' or 'distancing' from the speaker, a scale that he also sees in terms of graded similarity to noun-like thing-ness.It is not possible to touch on all these issues here, but it is worth noting the feeling of 'objectivity' (or 'distanced') quality of the *that*-clause is also reflected in the geometrical properties of the DSM: it is the magnitude of the vector from 0 to the space containing the *that*-clause. There is of course also a 'subjective' relation—that between *that*-clause and matrix clause—and the DSM shows this geometrically by using a coordinate transformation.

5.3.3 m-axes: conditional constructions as coordinate transformation

The interaction between *realis-realis* concepts associated with both tense and modality has often been noted. Linguists working with the notion of 'distance' (Fleischmann 1989) and with mental spaces (e.g. Sweetser 1996, Dancygier 1998, 2002) have shown how a coherent cognitive-linguistic account can be constructed. An initial assumption in the following account is that types of conditional sentence can be arranged, at least intuitively, in a scalar fashion in terms of their epistemic distance from the Speaker. Sentences (19) to (22) illustrate varying degrees of epistemic distance:

(19) John goes to the party, he will see Sarah
(20) If John went to the party, he would see Sarah
(21) If John had gone to the party, he would have seen Sarah
(22) If John had had a free day tomorrow, he would have gone to the party.

This assumption is also compatible with the observation (Declerk and Reed 2001, Dancygier 2002) that conditionals provoke the setting up of ‘spaces’ that are variously *realis*, *irrealis* or counterfactual. Because DST takes modal and temporal distance as intrinsic dimensions of discourse-based conceptualisations it is, in principle, well adapted to model the interaction between tense and the epistemic variation found in conditional sentences.

If constitutes a function that translates a copy of S’s coordinate system away from S’s reality plane to various points on S’s m-axis. How far it shifts depends on the tense forms together with verb meaning and contextual factors. There will also be a shift on t, determined partly by the verb tense and partly by contextual factors. The second set of axes is a ‘new reality’ space, similar to a Fauconnier mental space, except that ‘distance’ and ‘direction’ and deictic centring are built into the fundamental formalism of DST. Within the new set of axes, propositions that are dependent on *if* are represented. They are simultaneously ‘iffy’ with respect to S’s initial coordinate system, but ‘real’ within the new system. That is, all representations stimulated by conditional sentences are relative to 0′, the origin of the shifted axes. In the new space, anaphors find their antecedents and further embedded coordinate systems (‘spaces’) can be set up.

Taking examples (19) to (22) as representing the scalar possibilities of conditional sentences, Figure 17 models two examples that give rise to embedded coordinate systems whose origins are at different points on the epistemic m-axis: (19) is relatively close to, (20) relatively farther from the base system of S. What the DSM represents is conceptual structures evoked by what have become conventional meanings signalled by particular tense forms in the *if*-construction together with situational factors.

Figure 17
ABOUT HERE

The coordinates for *John*, *Sarah* and *party* are labelled in S's base coordinate system, but the vectors representing *go* and *see* are located in the translated coordinate system determined by the verb form. (For clarity the vectors are not shown in Figure 9/17.) The DSM for conditional sentences assumes that the verb in the protasis refers to an event prior to that referred to in the apodosis.

Thus in (19), *John goes to the party* would be 'real' (i.e. at m′ = 0) in the *if*-space but only 'likely' relative to S's reality plane. Interpreting the protasis of (20) as expressing a less likely eventuality than that of (19), the DSM would depict the origin of the embedded coordinate system as further away from the origin of the base system than is the case for (19). The new set of axes is relative to S's reality plane, i.e. the base coordinate system. But the new set of axes provides a discourse space, anchored to an epistemically questionable point on m, in which *irrealis* discourses can be set up. In all cases of conditional axis shift the new discourse space will include a new m-axis, which means that modal and negative representations in the apodosis can be modelled.

Let us consider now the counterfactual representations arising in (21) and (22). Assuming contexts in which these two examples have their full counterfactual reading, the differences between them (with respect to the question at issue) is one of time placement relative to S's coordinate system. The embedded systems each have coordinates m=neg (i.e. maximally distant from S); the t- and s-axes coincide with those of S. This means that the vectors occurring in the DSMs for (21) and (22) have coordinates m=neg, but for (21) $t < 0$ and for (22) $t > 0$. The value of t is determined by contextual factors as well as the tense of the verb. Figure 18 proposes one way in which we might construct a DSM for (21):

Figure 18
ABOUT HERE

As noted above, the embedded m-axis is required for cases where the apodosis evokes epistemic distancing of one kind and another. However, Figure 18 may not be optimal.

For we also need to take account of the fact that (22) illustrates polarity reversal, as does its negative counterpart, (23):

(23) If John had not gone to the party, he would not have seen Sarah.

It may be that interpreting a sentence like (23), in context and out of context, produce two simultaneous representations: one in which John did in fact go to the party (the *realis* representation) and one in which he did not (the counterfactual one). The converse is the case for (22). If this is the case, what is needed is a formal system that can somehow naturally model this. In the above discussion of conditionals we have used a form of translation of axes. But other transformations can be defined. The one that fits our needs for representing negative counterfactual sentences would translate a copy of the base coordinate system to the distal (negative) end of the m-axis and also rotate the entire coordinate system through a full circle, as shown for (23) in Figure 19.

Figure 19
ABOUT HERE

Figure 19 assumes that the discourse referents are first defined in S's reality plane, i.e. as proper names and definite phrases they presuppose existing antecedents. The vectors *go* and see lie in the negation plane of the embedded *if*-system and in S's reality plane in S's system. In other words, from the point of view, so to speak, of the *if*-sentence, the events of going and seeing did not happen, but from S's point of view they did happen.

Sentence (22) can of course be represented in the same diagram, by locating the vectors at m'=0, which means that from the viewpoint of the *if*-sentence the event did happen (*John had gone*), but simultaneously, in S's perspective, it did not. In general, for counterfactual conditional sentences we need the translation-plus-rotation transformation of the base coordinates. We can also see that polarity reversal, as instanced by counterfactual conditionals, can be defined in the present framework as a symmetrical reflection.

While further details of the above account need clarification, the general point is that transformation of axes yields an account of counterfactual conditionals that captures its key cognitive effects. Axis transformation, as we have argued throughout, arises in spatial cognition, but has quite abstract analogues in discourse space.

6 Concluding remarks

It hardly needs pointing out that this paper is exploratory. The most general is that the standard apparatus of elementary vector geometry provides a framework for giving coherent descriptions of conceptualisations of language input. Discourse processing is fundamentally deictic (or 'grounded', in Langacker's sense), and has a core that integrates spatial, temporal and 'modal' dimensions. The paper has focused on axis shifts. We have now seen the way an operation of axis shift appears in language processing in all three dimensions, spatial, temporal and modal. This is an operation that happens to be standard in vector geometry, but is also one that may be an intrinsic part of human spatial understanding and behaviour. Viewpoint phenomena have long drawn the attention of linguists: Langacker (1995: 210) points out that the viewing metaphor and its entailments underlie our attempts at description.

The discourse space we have explored is three-dimensional vector spaces, though it is clear that this limitation enables us to model only core characteristics of discourse processing. However, it is worth stating the hypothesis that a three-dimensional model along the lines outlined here is fundamental. The reasons for thinking this are that space, time and assessment of likelihoods can reasonably be thought to be of evolutionary significance. The peculiarity of the human species is that it can decouple such three-fold representations from immediate response reactions and, what is more important, communicate these representations through its language system. It is self-evident that that any such representation must be from an individual viewpoint, i.e. deictic. The ability to utilise landmarks other oneself to locate objects is probably of fundamental importance to many species. The ability to adopt alternative vantage points in time, and communicate them, is probably specific to humans. The ability to represent situations and events as less than real or contradictory to reality is probably unique. It depends on the communicator assuming an absolute epistemic vantage point while being able simultaneously to construct and communicate representations that differ from that point. One implication of DST is that this latter ability is an extension of the basic ability to basic viewpoint shifting in representations of physical space.

Considerations of this kind provide a further motivation for the use of vectors, one that is too big a topic to pursue in detail this paper. It should be noted, however, that neuroscientists in several fields of investigation have argued that relatively simple vector geometry is well adapted for the description of spatial orientation, navigation and viewpoint alternation (e.g. O'Keefe and Nadel 1978, O'Keefe and Burgess 1996, Gallistel 1990, Andersen 1995, O'Keefe 1996, 2003, Gärdenfors 2000). It is possible, furthermore, this is not accidental or a matter of methodological convenience but a reflection of the nervous system's own use of vector analogues.

The hypothesis that discourse space is built upon cognition of physical space is what makes DST an 'embodied' theory. That vectors may be part of the nervous system's in-built apparatus, that vectors may apply all the way through from spatial cognition to epistemic 'distancing', and that vectors are the formal scaffolding of DST is what makes the theory substantively 'embodied'. To be 'situated', too, has a basic physical meaning, the one that is characterised in terms of spatial and temporal deixis. But cognition is not trapped in egocentric coordinates: the vectors do not have to always take the viewing organism as the origin of the spatial coordinates but can shift the origin to relatively distant objects. Shift, of course, is only meaningful in relation to an initial coordinate system, that of the cogniser. The self as physical object is simply an organism that is situated in the sense of having coordinates and being able to establish a second set within that system. The epistemic dimension is a major cognitive leap that establishes 'situatedness'. The self is established not only as an object in space and time but in relation to possibilities and counterfactualities. An important extension of this line of thinking, which would take us too far afield for the present paper, is that it is possible in human discourse to shift to the epistemic vantage points of other cognisers and communicators, to their realties and unrealities.

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FIGURES

Figure 1: Prepositions as vectors (after O'Keefe 2003: 79)

Region denoted by preposition *behind*

Behind the box

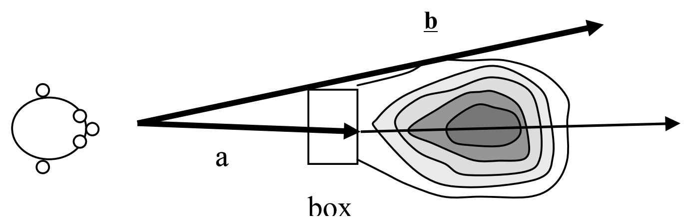


Figure 2: Egocentric representation of some spatial relations

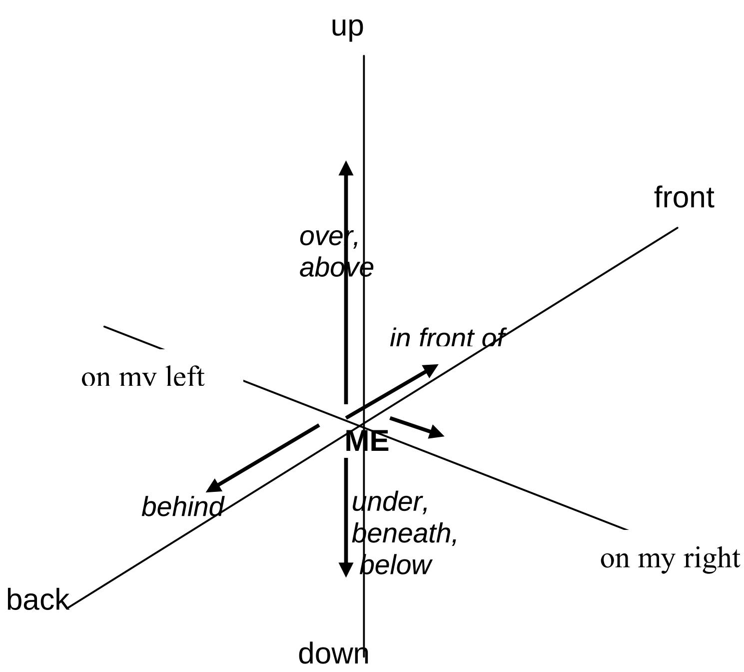


Figure 3: Relative distance from 0 on spatial axis

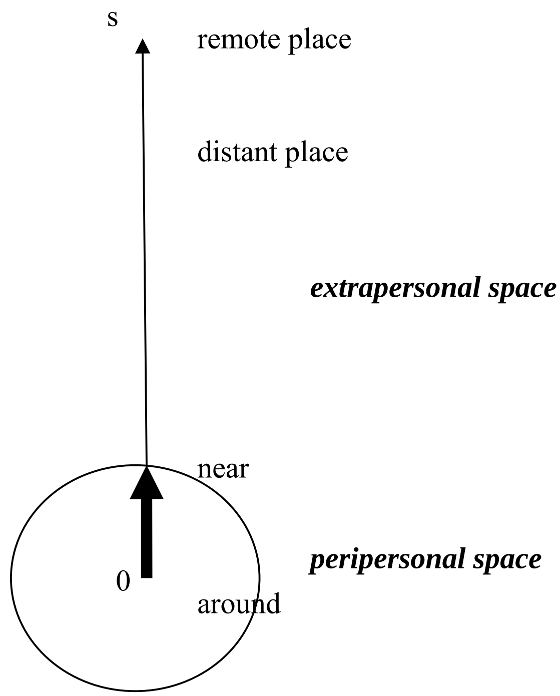


Figure 4 Spatial distance metaphorically 'rotates' onto temporal distance

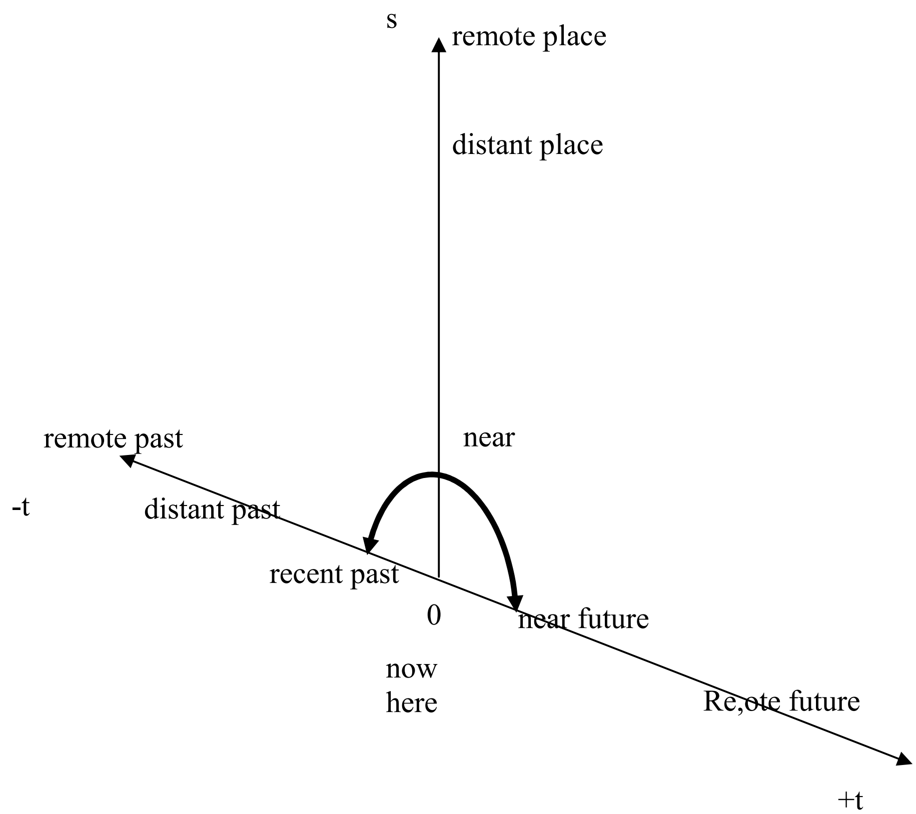


Figure 5: Spatial distance metaphorically 'rotates' onto modal distance

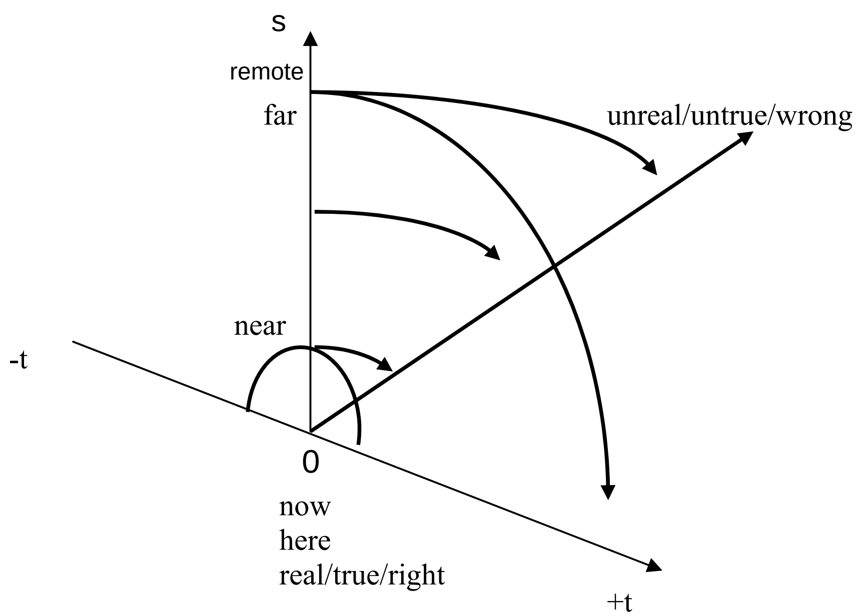
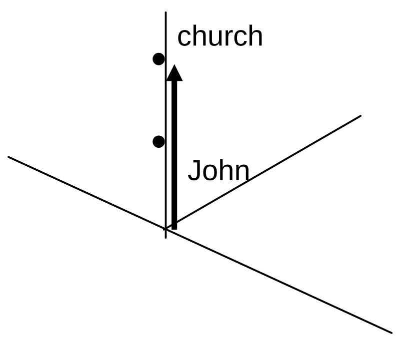
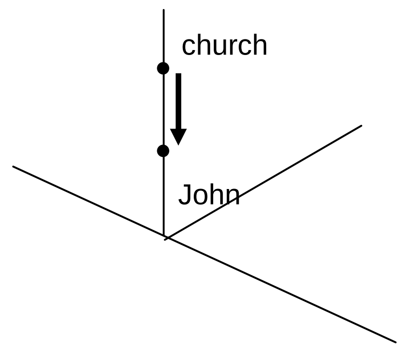


Figure 6 (i): Egocentric interpretation of (1) (ii): Allocentric interpretation of (1)



(i): Egocentric interpretation of (1)



(ii): Allocentric interpretation of (1)

Figure 7 *go* as translation vector

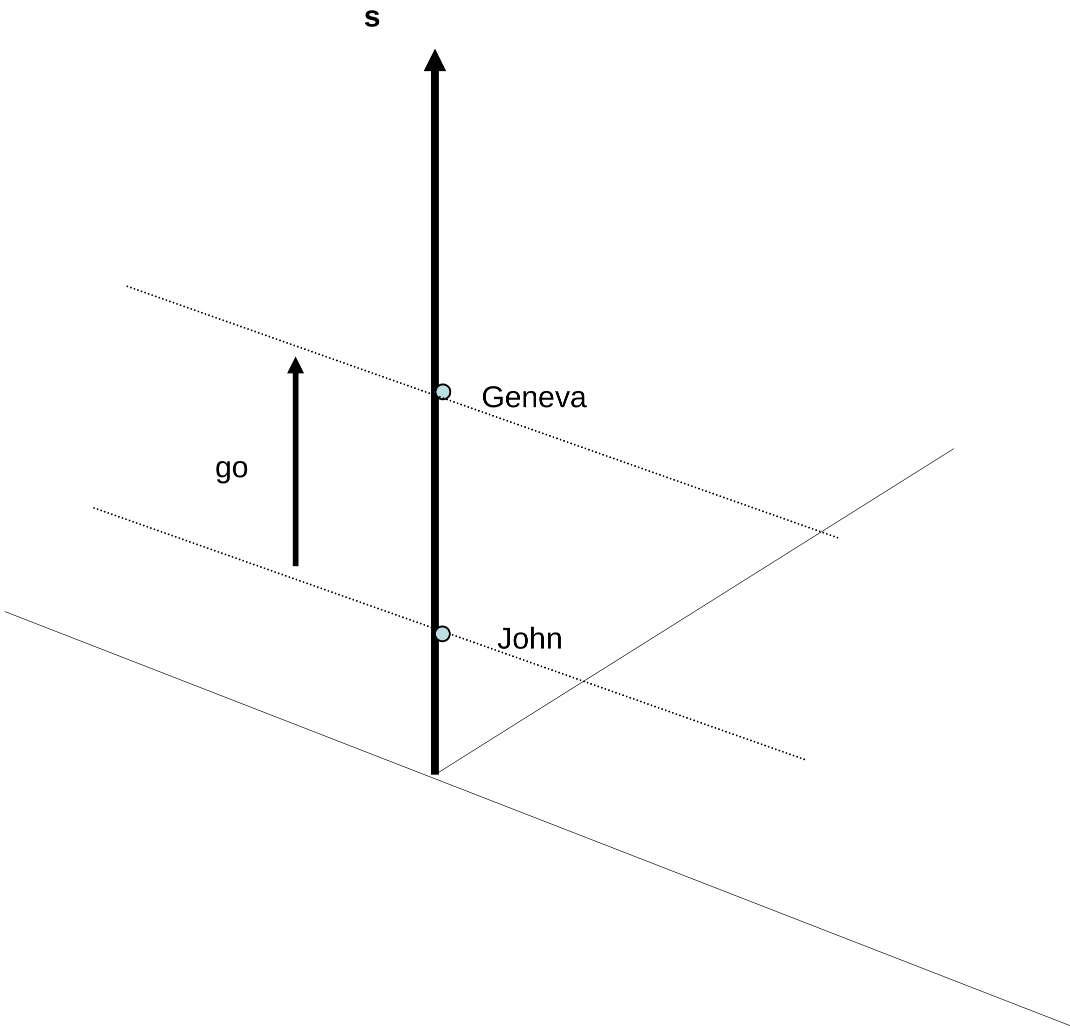


Figure 8 Deictic verb and translation of axes

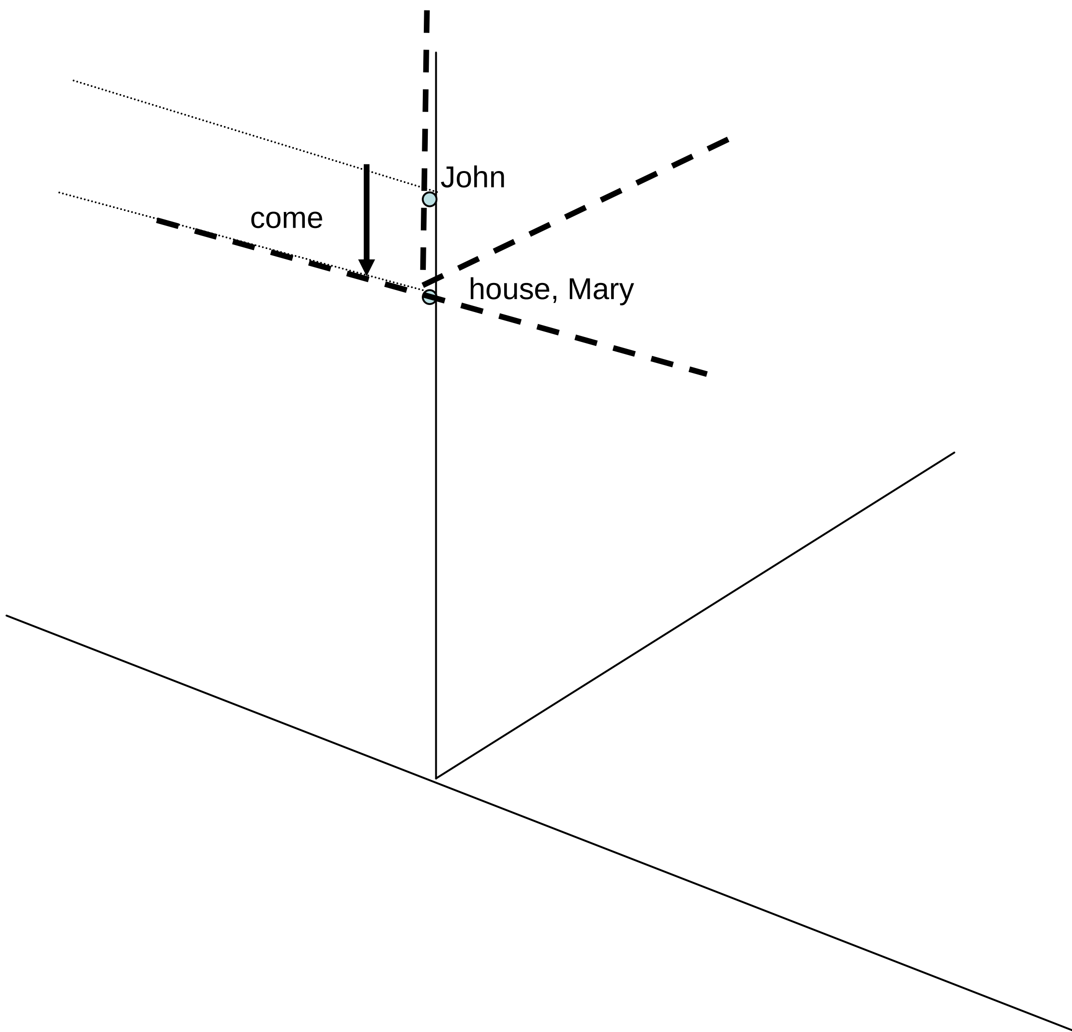


Figure 9 Translation and force

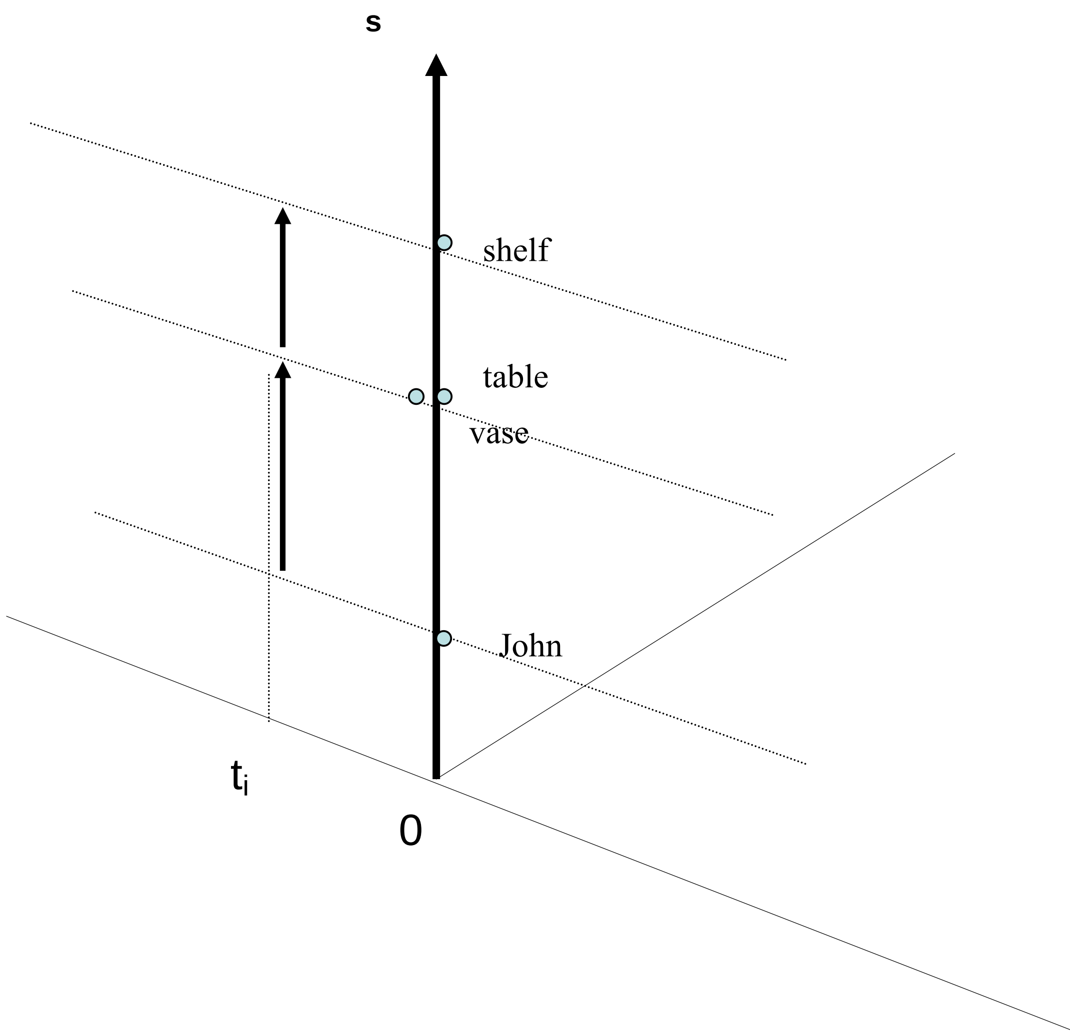


Figure 10 Present perfect

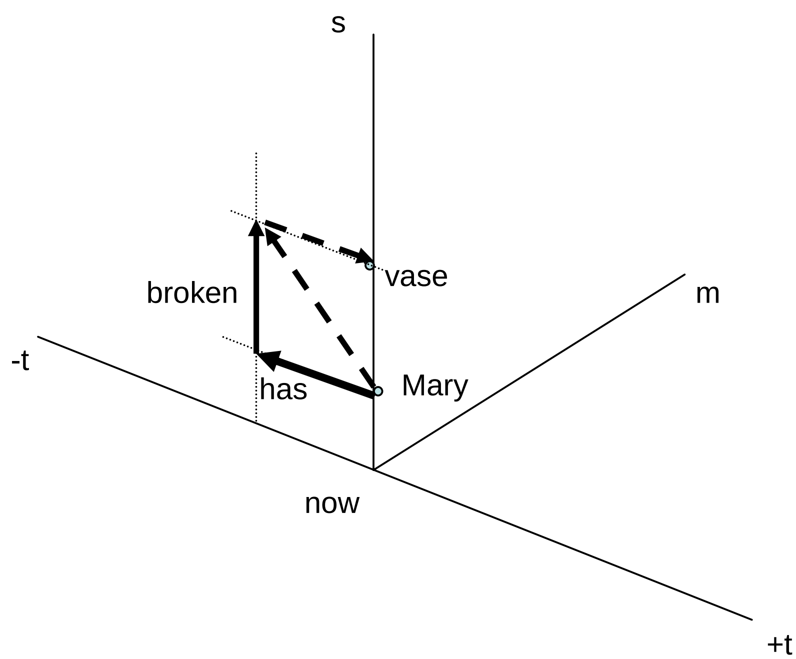


Figure 11 Past perfect

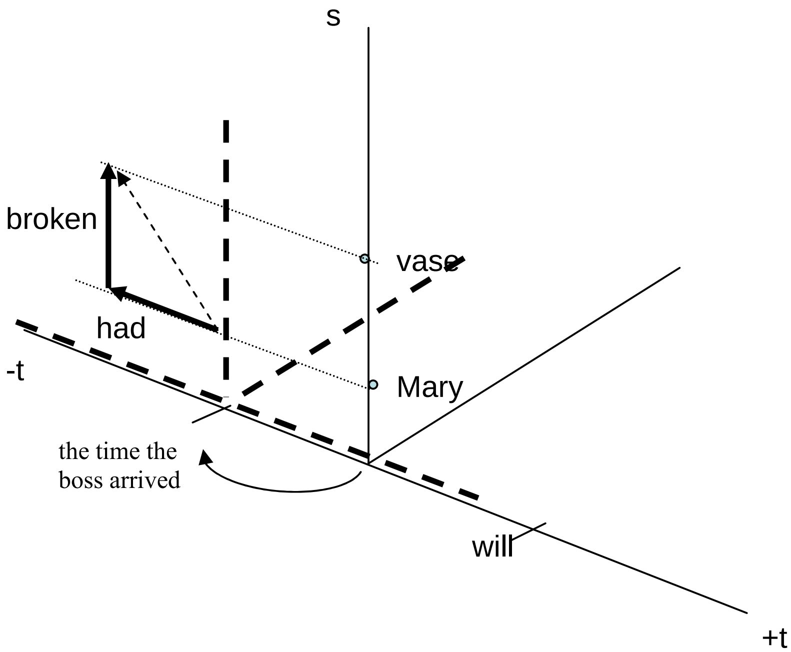


Figure 12 Future perfect

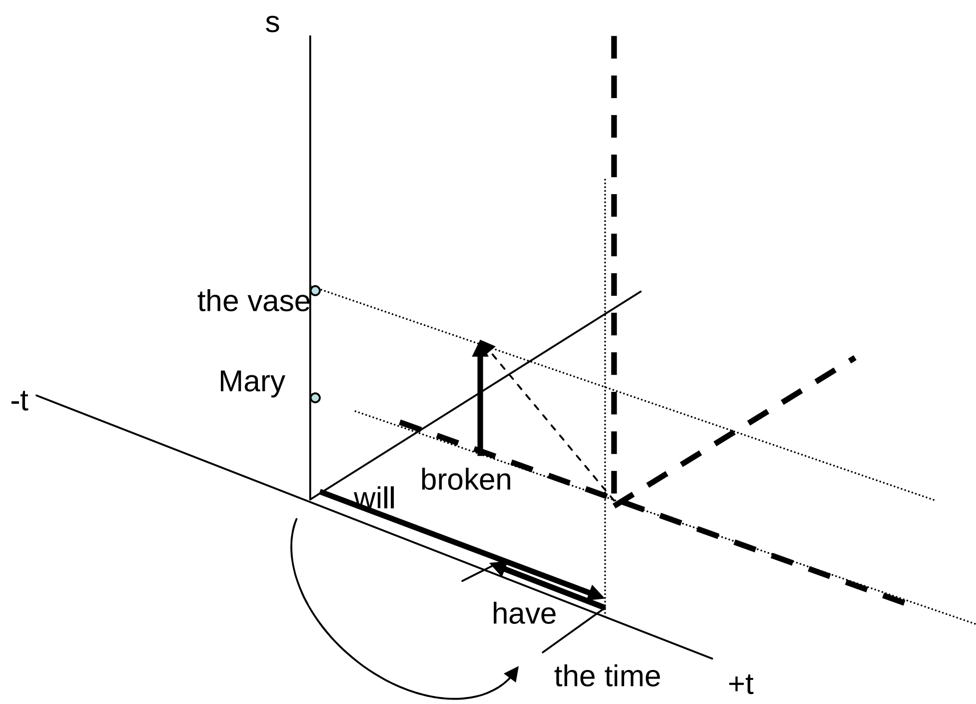


FIGURE 13 ***Realis* clause, complement of *know***

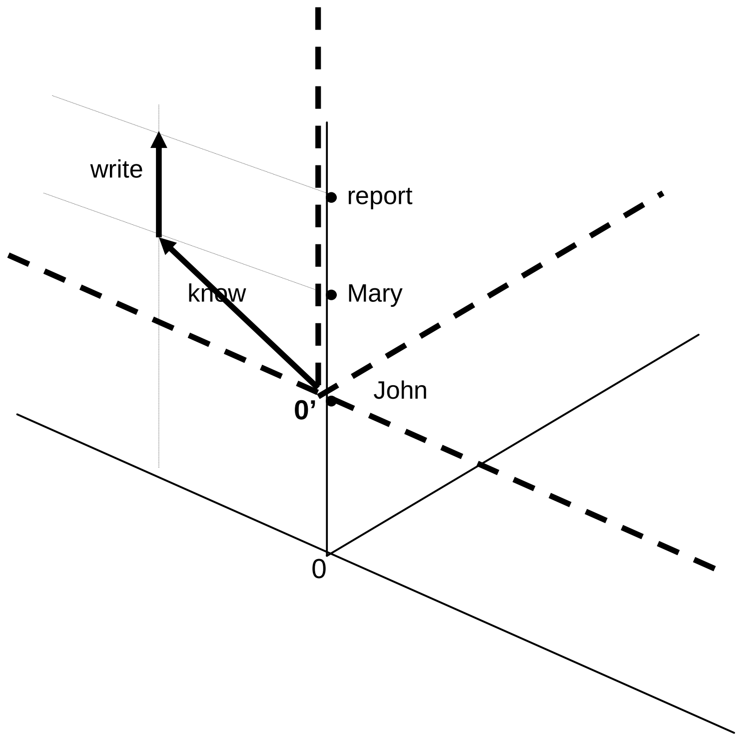


Figure 14 Effect of modal *might* in clause complementing *know*

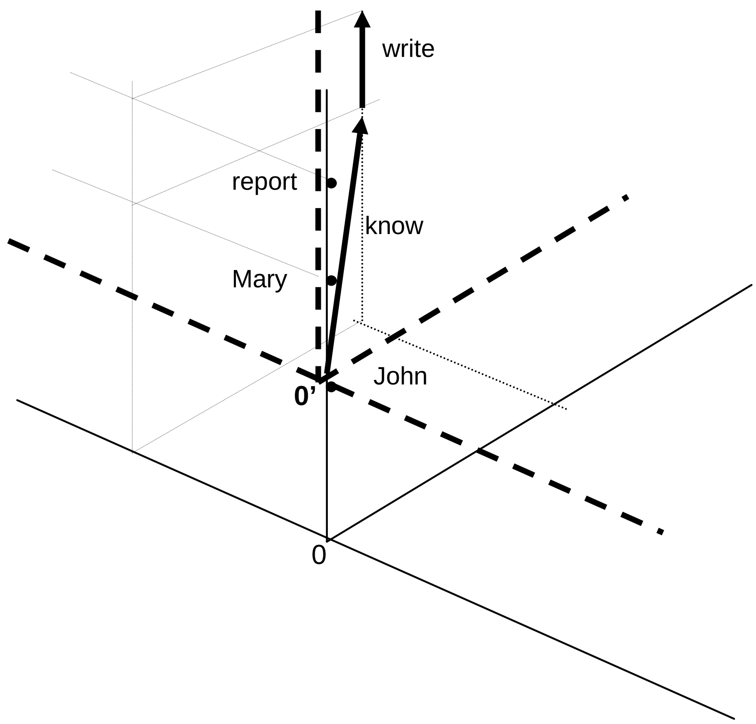


Figure 15 ***Believe*** **as coordinate shift on *m*-axis**

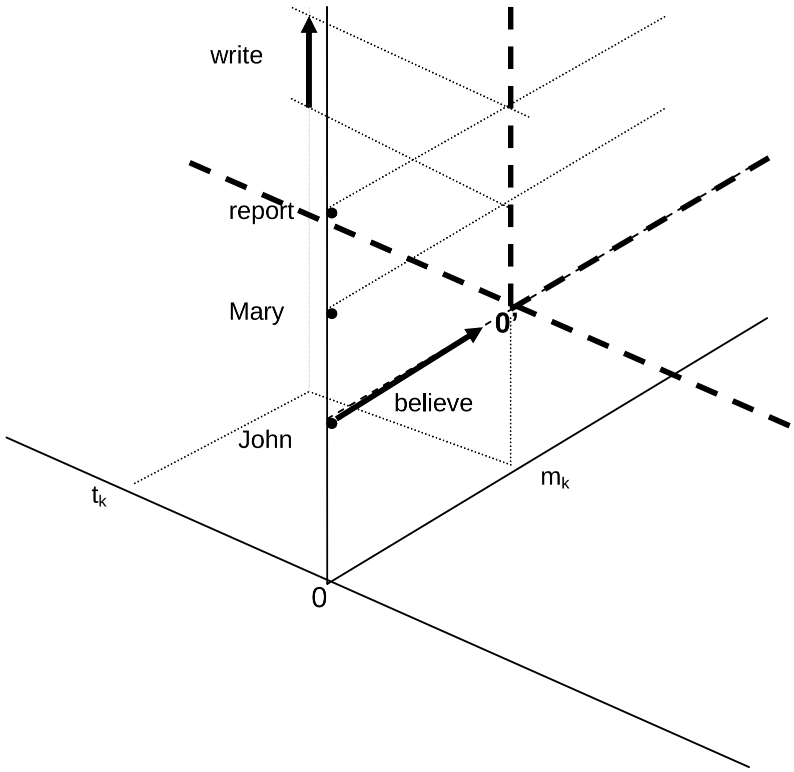


Figure 16 Effect of modal in *believe* complement clause

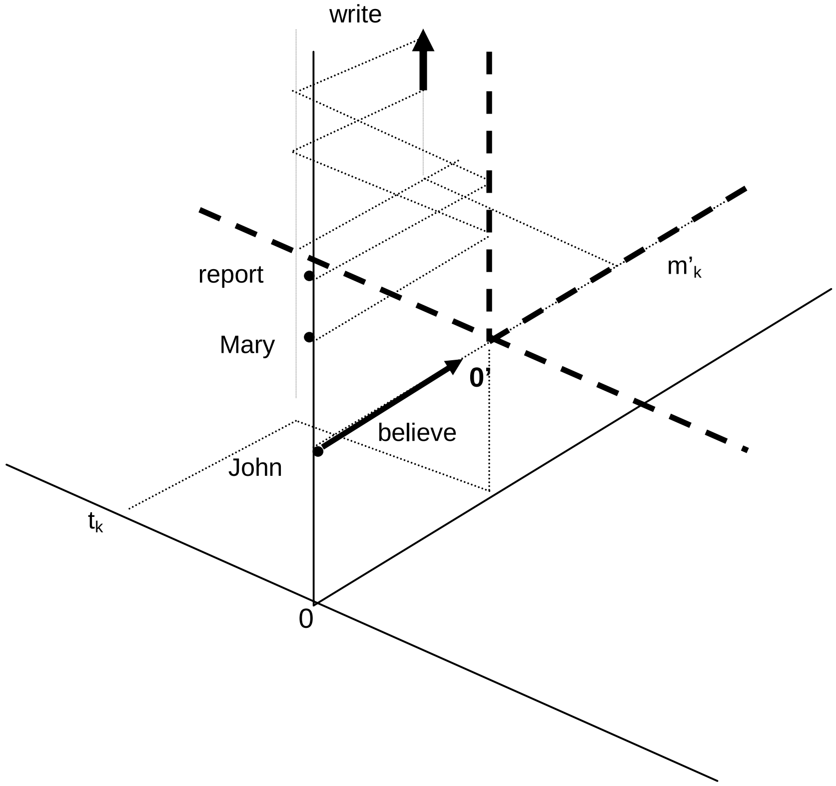


Figure 17

(19) If John goes to the party, he will see Sarah

(20) If John went to the party, he would see Sarah

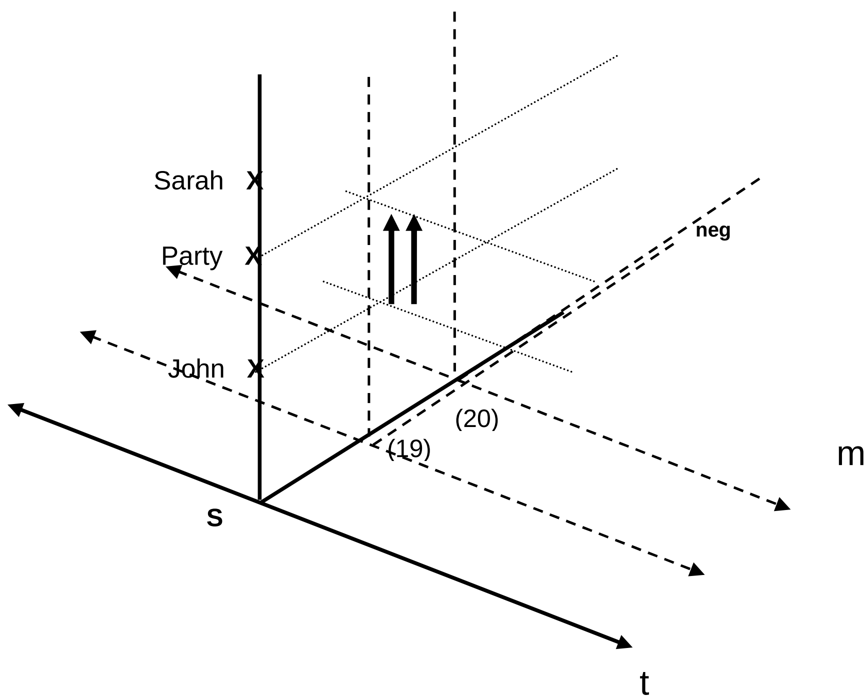


Figure 18
(21) If John had gone to the party, he would have seen Sarah

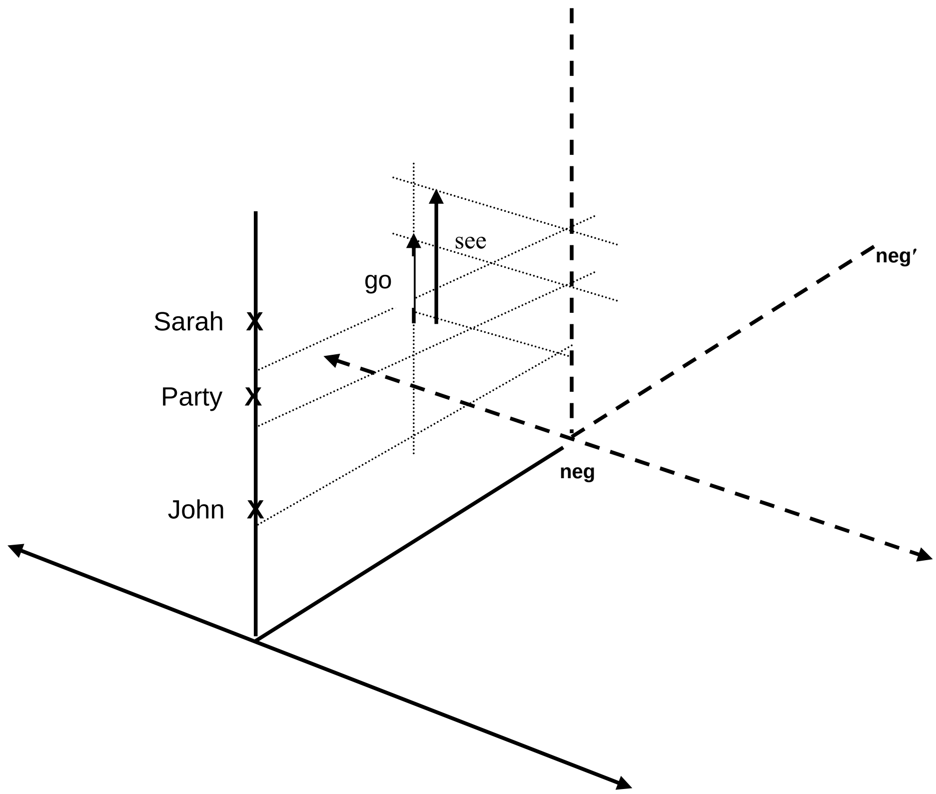


Figure 19
(23) If John had gone to the party, he would have seen Sarah