GIS COMMANDS AS *SMALL SCALE SPACE* TERMS: CROSS-CULTURAL CONFLICT OF THEIR SPATIAL CONTENT

Irene Campari

Department of Geoinformation
Technical University of Vienna
Gusshausstrasse 27-29
A-1040 Vienna, Austria
campari@geoinfo.tuwien.ac.at

ABSTRACT

GIS command languages are mostly written in English. These commands are verbs and terms that express cognitive models of native English speakers (NES). However, the GIS users' community is mostly composed of groups of non native English speakers (NNES). Each group of users expresses different cognitive models with respect to its native language. Different users' groups use different cognitive models to map the meaning of GIS commands. The translation of commands from English into other languages solves only the lexical problem. It does not address the conceptual problem of transferring meanings among different cognitive models expressed in different languages.

In this paper it is argued that difficulties in interpreting the spatial content of GIS commands by NNES users are due to the fact that commands are terms typical of the *Small Scale Space* (space of directly manipulable objects). *Small Scale Space* terms are adopted to interact with GIS that manages information about *Large Scale Space* (geographic and environmental space). NNES users activate first their common spatial cognition to understand GIS commands. This leads to distortions in understanding the meaning of commands. These may be interpreted literally, metaphorically, and, after the completion of a complex translation, technically.

This paper presents a case study on how NNES users' groups understand GIS commands as *Small Scale Space* terms.

1. INTRODUCTION

The terminology of command languages has become the standard vocabulary of GIS. Many GIS users have been trained on command languages. This remains relevant, although different interaction systems have been introduced (i.e., menu, windows oriented interaction). The terminology of command languages is used in training and education. Through GIS terminology, the

knowledge about GIS is transmitted. This knowledge is not merely technical. It is about geographic space, whose information is modeled and represented through GIS. Therefore, it is important to understand how different users' groups communicate about geographic space through GIS terminology.

Translating GIS terminology (i.e., command languages, manuals) from English into other languages does not solve the conceptual problem of communicating the spatial meaning of terms and sentences among different languages. The meaning of GIS commands and terms should be translated from cognitive models of designers into the cognitive models of users. This translation is a conceptual mapping that users do while they perform GIS commands. To do this mapping, users activate their common spatial knowledge organized in cognitive models and image schemas (Lakoff, 1988).

Users activate their common spatial knowledge to interpret GIS commands, because these are very often terms evoking meanings of common language and actions of everyday life. In particular, GIS terminology reminds users of scenes of actions where objects are completely under the users' control (i.e., a desk, a room). These scenes are typical of *Small Scale Space*. *Small Scale Space* is the space that can be apprehended from a single point of view (Kuipers, 1978; see also Zubin, 1989; Mark, 1992, 1993; Montello, 1993). Objects in it can be directly manipulated by the observer. This space has been defined in respect to *Large Scale Space* (geographic and environmental), whose structure cannot be observed from a single viewpoint, and objects in it cannot be directly manipulated by the observer.

The understanding of the spatial content of GIS commands by different groups of NNES users, is here discussed within the framework of *Experiential realism*. *Experiential realism* is an established set of theories advanced by Lakoff (1987) and Johnson (1987). The term *experiential* "is to be taken in the broad sense, including basic sensory-motor, emotional, social and other experiences of a sort available to all normal human beings- and especially including *innate* capacities that shape such experience and make it possible" (Lakoff, 1988, p. 120). *Experiential realism* focuses mostly on the idea that human cognitive models are influenced by interaction with the environment (Lakoff, 1980; Bateson, 1984; Varela, 1991; Winograd and Flores, 1986). The language transmits the environmental knowledge within specific cultures (i.e., through spatial metaphors and image-schemas) (Rosch, 1973, 1978; Tversky, 1983; Marvis, 1988; Putman, 1975; Lakoff, 1988; Talmy, 1983, 1993; Jackendoff 1983). The application of concepts from *Experiential realism* to understand geographic space has been recently discussed by Couclelis (1988), Mark (1989), Mark and Frank (1994).

1.1. Contents

This paper describes in section 2 the language as a basic differentiation among groups of GIS users and between users and designers. In section 3 the cross-linguistic analysis is proposed as the method to understand how NNES users understand GIS commands. In section 4 spatial concepts of GIS commands as *Small Scale Space* are analyzed. In section 5 the process of interpretation of spatial concepts of GIS commands by NNES users is described. In sections 6 and 8 a case study is presented about the interpretation of spatial concepts expressed in GIS commands by native Italian speaking users.

1.2. Goals

This paper aims to contribute to the understanding of the interaction with GIS by groups of users with different linguistic and cultural background. The importance of interaction systems for GIS has been already pointed out from different tasks and perspectives (Frank, 1993; Nyerges, 1993; Medyckyj-Scott, 1993; Monk, 1993). However, the analysis of everyday ways of interacting with GIS by different groups of users has received only little attention. The analysis of everyday interaction, based on concrete examples, such as GIS commands, has been claimed as a general methodology of investigation in the field of Human Computer Interaction (Carroll, 1990; Carroll, 1991; Barnard, 1991).

2. GIS DESIGNERS AND USERS: CULTURAL AND LINGUISTIC DIFFERENCES

Cultural differences have been addressed in their own right as research topics in the GIS field (Mark, 1987; Mark, et al. 1989; Svorou, 1988; Bjorklund, 1991; Gould, 1991; Mark, 1993; Goodchild, 1992; Campari, 1991; Campari and Frank 1993, 1994; Mark, 1993; Edwards, 1993), and in the general field of Human Computer Interaction (Kellog, 1993).

The language is a basic cultural differentiation among GIS users and between designers and groups of users (Mark and Frank, 1991). The GIS community consists of a designer community predominantly of NES and groups of NNES users.

Designers use professional spatial knowledge as well as common spatial knowledge (Davis, 1990) to design GIS interfaces (Carroll and Kellog, 1989; Carroll, Kellog and Rosson, 1991; Bannon and Bodker, 1991). The use of professional and common spatial knowledge is reflected in GIS terminology (i.e., choice of terms, explanation of commands, pictorial examples).

On their side, users use common spatial knowledge and professional knowledge to interact with GIS and to understand what they are doing. GIS commands represent a written language that gives users information to be interpreted. To interpret information users activate their mental models (Tversky, 1991). Each group of users exploits its own common spatial knowledge and professional knowledge to translate GIS terminology, and to transfer its meanings in various application domains.

3. CROSS-LINGUISTIC ANALYSIS

Cross-linguistic analysis is a comparative methodology. It is based on the comparison of expressions in different languages to describe similar spatial situations. Tversky and Hemenway pointed out that: "distinctions that are important for human perception, behavior, and communication will be reflected in language" (1983, p.4). Language has a role in structuring the sense of 'where you are' and the 'method of loci' (Neisser, 1986; Lynch, 1960; Norberg-Schultz, 1979; Gould and White, 1986). Cross-linguistic analysis, crucial for the cross-cultural approach, has been recently stressed in the GIS research field (NCGIA Initiative 2, 10, 12, 13; Frank, Campari and Formentini, 1992; Frank and Campari, 1993).

Despite the theoretical attention, only a few investigations have been undertaken on spatial knowledge expressed, communicated and interpreted in other idioms than English . Cross-linguistic analysis should be based on researches on spatial expressions of each idiom (Mark, et. al, 1989; Pederson, 1993). Herskovits (1985, 1987) studied the spatial expressions and prepositions in English, but there is nothing comparable for other idioms. Only recently attempts have been made to study spatial expressions in German, French and Italian (Wienold and Schwarze, 1990; Habel, 1989; Wunderlich and Herweg, 1990; Maierborn, 1990; Casadei, 1993).

4. GIS COMMANDS AND SPATIAL CONCEPTS OF SMALL SCALE SPACE

GIS commands are verbs and terms that express spatial concepts of *Small Scale Space* environments. They refer to manipulation of objects under the users' visual control. GIS commands evoke to users scenes of actions with configuration of objects in defined spatial situations of *Small Scale Space*. Scenes of *Small Scale Space* are built on the egocentric position of the user. Users imagine scenes of spatial actions, configuration of objects and gestures that are under their control.

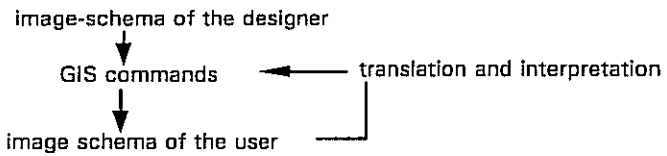
Mark (1992 1993) named *Haptic Space*, a particular type of space users employ to interact with GIS. *Haptic space* is primarily based on sensori-motor, haptic perception and bodily experience. Scenes users imagine are typical of

the space of type *A* proposed by Zubin (1989; see also Couclelis, 1992), and reconsidered in HCI as *Haptic Space* by Mark (1992, 1993). Space of type *A* includes objects that are:

- less than or equal to human size,
- contained in a static visual field,
- manipulable by human beings, or at least are highly movable,
- 'omni-perspectival' (they can be freely rotated, both as physical objects or by 'mental rotation').

5. INTERPRETATION OF SPATIAL CONCEPTS OF GIS COMMANDS BY USERS

When users perform GIS commands they try to interpret them. Commands remind users of common metaphors and imagery rather than of technical and professional acts. This complex imagery is distantly related to actions that GIS is supposed to perform through commands. This becomes apparent when users have a different mother tongue to that used in GIS, in this particular case English. The imagery suggested to users by GIS commands refers to an image-schema different to that of the English language. During the process of understanding GIS commands, users perform a translation of the English image-schema into an image-schema of their own language. The process may be summarized as in the following scheme:



Languages differ in expressing spatial terms. There is not always a corresponding spatial verb or term for the same context, among different idioms. GIS commands often have no direct correspondence with the spatial meaning of terms in languages into which they are translated. Terms can be translated, but during translation spatial meanings may change or be substituted by other terms with different spatial connotation. To get some correspondence among spatial meanings, NNES users go through several steps, as follows:

a) translating the GIS command into a common term in their language,
b) imagining an action in an everyday situation suggested by the common term in their language,
c) searching for a technical term in their language,
d) searching for a corresponding technical term in English,
e) searching for a corresponding technical term in an application domain,

f) performing the GIS command.

6. THE CASE STUDY

The case study focuses on the analysis of some ARC/INFO commands, and how their spatial meaning is perceived by Italian users. The case study is limited because:

- the analysis accounts for only one GIS (albeit one of the most widely used),
- it concentrates only on command language, since this offers a simple way to analyze the basic GIS terminology,
- methodologies to investigate these topics are not well developed yet.

Considering the GIS terminology as merely technical and professional is not a way to escape from its cultural dependency. It does not solve the problem, indeed it makes issues culturally more complex.

6.1. The user

For this discussion, we assume the user possesses a high level of education, a good command of the mother tongue, a scholastic knowledge of English. The educational background may be in different disciplines and fields related to GIS applications. This background allows users to question about the meanings of GIS commands and terms, and about the correctness of the actions they perform with them.

6.2. The spatial model of GIS

The spatial model implemented in GIS plays an important role in the interpretation of spatial concepts expressed in GIS commands. For instance, ARC/INFO implements a model of space in which objects are spatially defined on a fixed coordinate grid. All the locations in which an object may occur are predefined. Commands do not suggest questions like 'where' (place) an object is located in the world. They suggest questions about 'what' (thing) is located in the coordinate frame. Places ('where') and things ('what') belong to different ontological categories, and are primitives of conceptual structures (Jackendoff, 1983). 'Where' and 'what' suggest different questions and answers. With 'where' entities are located, with 'what' entities are defined in a context.

Systems managing spatial information are supposed to suggest and to answer the question 'where'. Where this does not happen, it takes users to fill the gap using their common spatial experience. For instance, when the command ALIGN is performed, the user asks first 'what' has to be aligned, rather than 'where' objects have to be aligned. The command ALIGN suggests to an Italian

user an action of locating objects in a left-right sequential order. The spatial action is imagined as occurring on a desk or in a room.

7. GIS COMMANDS: AN EMPIRICAL TAXONOMY

An empirical taxonomy of GIS commands and terms is here proposed to proceed systematically with the analysis of examples. GIS commands and terms are subdivided into terms that define objects and their configuration, commands that are substantives and nouns with common meaning, commands suggesting spatial scenes with actions. Commands are separated from object terms. Both of them may belong to the GIS jargon.

Terms that define objects and their configuration are:

- COVERAGE, ENTITY, VERTEX, NODE, EDGE: nouns of GIS objects.

An example of a command as a substantive is:

- GRAIN: to check the consistency of entities on a map.

Commands suggesting actions in spatial scenes are:

- GENERATE, CREATE: to create new empty maps and workspaces;
- APPEND, JOIN, OVERLAY, MATCH, INTERSECT: to relate coverages;
- BUILD, CLEAN: to check the topological consistency of a coverage;
- DISSOLVE, DENSIFY: to eliminate or add entities;
- ADD, ALIGN, ADJUST, DROP, EXTEND, FLIP, MOVE, SPLIT: to edit and smooth entities on coverages;
- CONSIST: to check the logical consistency of entities codes.

These commands are verbs always used in the present tense. They often suggest static situations. Even in a progression of commands that modify previous actions, users interact with verbs in the present tense. Their meaning is captured by users as verbs of 'state' and not verbs of 'event'. Users only seldom get the evolution of the 'event' while they are performing a sequence of commands. These are perceived singularly as verbs of 'state' (Jackendoff, 1983).

In the next sections, terms and commands in these three groups are examined simultaneously to show the conceptual conflict.

7.1. GIS Commands With Common Meanings: Example *Coverage*

The Italian literal translation of the terms COVERAGE, used in training manuals, and COVER, used in the interface dialogue, is *copertura*. *Copertura* is a substantive corresponding to the verb *coprire*. *Coprire* refers to two different actions.

The first action is hiding portions of objects by another floating object, that fits with the shape of hidden objects. Metaphorically, this action has two meanings. Hiding something is like making it unknown (*ignoto*). Spatial metaphors for this action are defined by using the prepositions *dietro* (back), *sotto* (under) and *su* (over) (Casadei, 1993). Johnson (1987) and Talmy (1983) interpreted the metaphorical use of those prepositions as due to the bodily experience expressed in language. *Dietro* (back) refers to a part of the human body. Metaphorically, *dietro* points to a position of inferiority, or a backward location (invisible) with respect to the speaker's position. *Su* refers to an unreachable location with respect to the bodily dimension of the speaker.

The second action recalled by COVER is that of protecting something or somebody. In Italian the spatial metaphor of protection is expressed by prepositions such as *sotto* (under) and *dentro* (in). *Dentro* (in) refers to the 'container' metaphor (Lakoff and Johnson, 1980). An Italian user perceives the stratification of coverage layers as real objects containing other objects. However, in GIS terminology, COVER is a virtual map layered over other maps. COVER has the meaning of adding something rather than of protecting. In GIS the meaning of stratification is that of putting 'on' - 'platform' metaphor - rather than of hiding 'inside' or containing 'in'.

7.2. GIS Commands as Substantives: Distortions in Mapping

GIS commands are assumed to be verbs of action. A common distortion happens when a GIS command is a substantive, and it has no corresponding verb in the target language. The spatial meaning of actions performed by such commands does not fit into the spatial concept of the user's language.

The GRAIN is a common English word. In GIS terminology, GRAIN controls and sets actions of generalization and densification of arcs. GRAIN is a command and an Italian user will look for a corresponding verb in Italian. However, there is not a corresponding verb in Italian. Whether GRAIN is assumed as a substantive, the Italian literal meaning is *grano* (of corn) or *granularita* (of material). The reference meaning is to the texture of a sheet or to the support, rather than to what is on the sheet or support.

The GRAIN command checks the distance among VERTEXs of arcs. The translation of the concept involved in this command leads to the following Italian sentence: *controllare e ristabilire le distanze tra i vertici dell' arco.* But a large number of other concepts may be evoked, i.e.: *controllare e ristabilire l' andamento* (trend) *dell' arco tramite sfoltimento o addensamento dei suoi segmenti.* Given the meaning of the substantive GRAIN in Italian, VERTEXs are assumed to be those of the sheet, and not ENTITIES on it. To get the meaning of this action into GIS context, users should take for granted that ENTITIES on the screen are identified with the support they are on.

The CONSIST command controls the ENTITIES codes on maps. The Italian literal meaning of CONSIST refers to the verb *consistere di* (to be composed of) and to the substantive *consistenza.* The concept involved reminds of the consistency of supports, rather than of the relations of ENTITIES on it. In manuals, the explanation of the function of this command corresponds to concepts related to the English term consistency, to be translated in Italian with *coerenza.* However, in Italian, *coerenza* refers to moral and ethic domains, not to material ones. The conceptual content of *coerenza* may not be assumed to be synthetically translated with CONSIST. To get a correct reference, the translation should be resolved with the following sentence: *controllare la coerenza logica di x rispetto a y nel context z* (checking the logical consistency of x as to y in the context of z). The action of checking points to the question 'what' is consistent with, and not 'where' something is consistent with something else in a specific context. In the Italian translation the user has to imagine a context 'where' the action of checking the consistency occurs. Therefore, the user has to find out a specification for the substantive *coerenza.* This explains the long sentences necessary to make the command CONSIST acceptable for an Italian user.

7.3. GIS Commands and Terms With Conflicting Spatial Meanings

VERTEX (*vertice*) is a simple noun that may lead to misunderstanding. The Italian translation is *vertice. Vertice* is intended (in a metaphorical sense too) to be an ending position of a continuous bottom-up action. Nothing higher exists beyond the VERTEX position. VERTEXs of a horizontal action are called *estremi* (extreme points). In GIS terminology the VERTEX is intended to be the snapped point of a link of an arc. Such a VERTEX is related to the context of an arc, whose end points are nodes. The term NODE does not involve the spatial concepts expressed by the Italian term *vertice.* The node is not the highest or the extreme position in this context. In Italian NODE (*nodo*) corresponds to terms such as KNOT or JUNCTION.

This conceptual variation from English to Italian affects the understanding of operations such as ALIGN. Users think of actions of alignment as 'getting a

straight line perpendicular to their point of view. The action is imagined in terms of the user keeping the VERTEXs (ending points) fixed. The resulted figure is an equilateral triangle whose user's point of view is one of the VERTEXs. Actually, in terms of GIS functions all the points on a line are dynamic VERTEXs. This creates a counter-intuitive situation that may have an impact on the configurational reasoning of users.

An example of a conceptual conflict in the spatial meaning of terms is provided by the command EXTEND. This is used to smooth entities on a map. This command may be misunderstood by an Italian user for the following reasons:

a) the corresponding verb in Italian is *estendere*. It refers to the spatial metaphor of expanding on an idea or a concept (*estendere un concetto*). It may also refer to the action of extending a property of land, with emphasis on the concept of property;

b) in GIS terminology EXTEND refers to a linear feature, while in Italian it refers to areal features. 'A road may extend from New York to Albany', is common in English (Jackendoff, 1983). In Italian only areal features may be extended.

7.4. GIS Commands: Contrast of Meaning in the Target Language

There are cases in which spatial terms are not translated because of the conflict in spatial meanings. Generally, these terms involve too generic concepts. They are sort of high level terms in a possible taxonomy of GIS terminology. For instance, MATCH is not translated in Italian since it may lead to a conflict of meanings. The verb 'to match' or the substantive 'the match' may be translated in different concepts, as follows:

- *opporre* (to be or put against) and *incontro/scontro* (meeting/fighting);
- *combinare* (to combine) or *accoppiare* (to pair off) and *unione* (union) or *accoppiamento* (joining).

In Italian the common meaning of MATCH is generally related to the first of these. While in GIS, the command MATCH has to be understood with the second option of meaning (*unione*). The term *unione* is also used, generically, to point to other GIS commands such as APPEND, JOIN, RELATE, performing different functions than MATCH.

8. LANGUAGE EVOLUTION

GIS commands use common words and give them a special meaning. This seems a very common method, rapid and smooth too, of language evolution in contemporary English. The process is more restricted in other languages, and

this may create a discrepancy. The discrepancy with the conceptual and spatial meaning of English words is relevant and sometimes substantial, as in the following examples:

MOVING: (*muovere*) in Italian, without any specification of moved objects, corresponds to a continuous action in space and time. The English common meaning is that of shifting an object between known points. In the current GIS terminology, MOVE recalls the meaning of the Italian verb *spostare* (shifting). Its meaning involves the concept of moving from a fixed point to another fixed point, defined in space and time. In Italian, only in chess terminology does MOVE has the same meaning as in GIS: an action performed on a flat surface, among fixed positions.

APPEND: (*appendere*) is a GIS function used to attach a map to another one. The Italian *appendere*, without any proposition, means 'appending a thing to the bottom of another or on another one'. This action results in a hanging position of the moved object. The spatial concept involves a top-down movement. An Italian user would imagine a surface on which the object is located. The object remains distinct on the surface. The command APPEND recalls an action of moving objects in a *Small Scale Space* (i.e. appending a frame on a wall). In Italian, APPEND has a metaphorical meaning of finding a place for ordering things. APPEND should then suggest the question 'where'? In GIS the coordinate frame for this operation enforces a correct interpretation and prevents some misconceptualizations. In future systems, the use of a coordinate grid might be less diffused, thus differences in spatial imagination might become more significant in the effective use of the systems.

CLEAN: (*pulire*) is a GIS function, supporting vector or topological data models. The command CLEAN constructs topological relations among geometric entities of a coverage. In Italian, the meaning of CLEAN is only that of cleaning up something, taking off dirt. The inferred technical meaning may be best referred to as the action of 'cleaning up' performed on a dirty COVER-map, that sounds like: 're-constructing the topology of the map, removing overshoots and stretching undershoots, by applying some parameters'. In GIS terminology, the command CLEAN only points to the ancillary function of the whole task (removing overshoots and undershoots) it is supposed to do (construction of the topology). The Italian *pulire* presupposes something existing under a dirty layer. In GIS terminology the action of cleaning is performed on a map whose dirty layer is an integrated part of the cleaned one.

DISSOLVE: (*dissolvere*) is a GIS function that merges adjacent polygons. The Italian *dissolvere* points to a centripetal or centrifugal action of dissolving. After dissolving, only an "unshaped" surface remains, or an empty space. While the GIS command DISSOLVE assumes as a result a bounded space between two

removed areas. The Italian meaning has a "nihilistic" connotation rather than a constructive meaning. Usually in Italian *dissolvere* comes with adverbs like 'quickly' or 'slowly', giving the action of dissolving a temporal meaning. The action of dissolution is metaphorically intended as a complete disappearance of something and somebody. It is meant as the action of melting an entity into another to get a complete fusion. Actions of melting are always imagined to occur in a *Small Scale Space* (i.e. on a table in a glass).

9. CONCLUSIONS

In this paper a case study of how NNES users understand GIS commands is presented. The analysis is made within the theoretical framework of *Experiential realism*, and the methodological framework of cross-linguistic analysis. The problems tied to the understanding of GIS commands by different user communities are varied and exist at different levels.

This paper stresses the character of GIS commands as *Small Scale Space* terms. Issues involve the communication among different spatial conceptual domains, in particular that of GIS designers and that of groups of users with different cultural and linguistic backgrounds. To face these issues a deep analysis of the spatial conceptual domains of GIS designers and of different groups of users should be undertaken.

REFERENCES

Bannon, L.L., Bodker, S. (1991), *Beyond the Interface: Encountering Artifacts in Use*, in Carroll, J.M. (Eds.), *Designing Interaction*, Cambridge: Cambridge University Press.

Barnard, P.J. (1991), Bridging Between Basic Theories and the Artifacts of Human Computer Interaction, in Carroll, J. M. (Ed.), *Designing Interaction*, Cambridge: Cambridge University Press.

Bateson, G. (1984). *Mente e Natura*. Milan: Adelphi.

Bjorklund, E. M. (1991), Culture as Input and Output of the Cognitive-Linguistic Processes, in Mark, D.M., Frank, A.U. (Eds.), *Cognitive and Linguistic Aspects of Geographic Space: An Introduction*, Dordrecht: Kluwer Academic: 66-70.

Campari, I. (1991). Some Notes on Geographic Information Systems: The Relationship Between their Practical Application and their Theoretical Evolution, in Mark, D., Frank, A.U. (Eds.), *Cognitive and Linguistic Aspects of Geographic Space*, Dordrecht: Kluwer Academic: 35-44.

Campari, I., Frank, A.U. (1993), Cultural Differences in GIS. A Basic Approach, in *Proceedings of EGIS'93*, 1, Genova: EGIS Foundation: 10-17.

Carroll, M.J. (1990), Infinite Detail and Emulation in an Ontologically Minimize HCI, in *CHI'90, ACM-SIGCHI Bulletin*: 321-327.

Carroll, M.J., Kellog, W. (1989), Artifact as Theory Nexus: Hermeneutics Meets Theory Based Design, in Bice, K., and Lewis, C. (Eds.), *CHI'89, SIGCHI Bulletin*, 7-14.

Carroll, M.J., Kellog, W.A., Rosson, M.B. (1991), The Task-Artifact Cycle, in Carroll, M.J. (Ed.), *Designing Interaction*, Cambridge: Cambridge University Press: 73-102.

Casadei, F. (1993), The Canonical Places: An Implicit (Space) Theory in Italian Idiom, Ph.D. *Dissertation*, University of Rome "La Sapienza".

Casadei, F. (1993), The Canonical Place: An Implicit (Space) Theory in Italian Idioms, in Casati, R., White, G. (Eds.) *Philosophy and the Cognitive Sciences, XVI Wittgenstein Konferenz*, Austria: Kirchberg.

Couclelis, H. (1988), The Truth Seekers: Geographers in Search of the Human World, in Golledge, R., Couclelis, H., Gould, P. (Eds.), *A Ground for Common Search*, Santa Barbara: The Santa Barbara Geographical Press: 148-155.

Couclelis, H. (1992), People Manipulate Objects (But Cultivate Fields): Beyond the Raster-Vector Debate, in Frank, A.U., Campari, I., Formentini, U. (Eds.), *Theories and Methods of Spatio-Temporal Reasoning in Geographic Space*, Lecture Notes in Computer Science, Vol. 369, Heidelberg-Berlin: Springer Verlag: 65-67.

Davis, E. (1990), *Representation of Commonsense Knowledge*, San Mateo: Morgan Kaufmann Publ.

Edwards, G. (1993), The Voronoi Model and Cultural Space: Application to the Social Science and Humanities, in Frank, A.U., Campari, I., (Eds.),*Spatial Information Theory: Theoretical Basis for GIS*, Lecture Notes in Computer Science, Vol. 716, Heidelberg-Berlin: Springer Verlag: 202-214

Frank, A.U. (1993), The Use of Geographical Information System: The User Interface Is the System, in Medyckyj-Scott, D., Hearnshaw, H.M. (Eds.),

Human Factors in Geographical Information Systems, London: Belhaven: 3-14.

Frank, A.U., Campari, I., Formentini, U. (1992) (Eds.),*Theories and Methods of Spatial Temporal Reasoning in Geographic Space*, Heidelberg-Berlin: Springer Verlag.

Frank, A.U., Campari, I., (1993) (Eds.), *Spatial Information Theory: Theoretical Basis for GIS*, Lecture Notes in Computer Science, Vol. 716, Heidelberg-Berlin: Springer Verlag.

Golbeck, S.L. (1985), Spatial Cognition as a Function of Environmental Characteristics, in Cohen, L. (Ed.), *Development of Spatial Cognition*, London: Lawrence Erlbaum Ass. Publ.: 225-255

Goodchild, M. (1992), Hard Challenge and Opportunities in GIS Related Researches, in *University of British Columbia Meeting on GIS*, British Columbia.

Gould, M.D. (1991), Elicitation of Spatial Language to Support Cross-Cultural Geographic Information Systems, in Mark, D., Frank, A.U. (Eds.), *Cognitive and Linguistic Aspects of Geographic Space*, Dordrecht: Kluwer Academic: 435-448.

Gould, P., White, R. (1986), *Mental Maps*, Allen & Unwin.

Habel, C. (1989) (Ed.), *Raumkonzepte in Verstehensprozesses*, Tübingen: Niemeyer.

Herskovits, A. (1985), Semantics and Pragmatics of Locative Expressions, *Cognitive Science*, 9: 341-78.

Spatial Cognition: An Interdisciplinary Study of the Prepositions in English, Cambridge: Cambridge University Press.

Jackendoff, R. (1983),*Semantics and Cognition*, MIT Press.

Johnson, M. (1987),*The Body in the Mind*, Chicago: University of Chicago Press.

Kellog, W.A., Thomas, J.C. (1993), Cross-Cultural Perspective on Human Computer Interaction: A Report on the CHI'92 Workshop, *SIGCHI Bulletin, 25, 2*: 40-45.

Kuipers, B. (1978), Modeling Spatial Knowledge, *Cognitive Science*, 2:129-153.

Lakoff, G. (1987), *Women, Fire and Dangerous Things*, Chicago: University of Chicago Press.

Lakoff, G. (1988), Cognitive Semantics, in Eco, U., Violi, P., Santambrogio, M. (Eds.), *Meaning and Mental Representation*, Indiana University Press:119-154

Lakoff, G., Johnson, M. (1980), *Metaphors We Live By*, Chicago: University of Chicago Press.

Lynch, K. (1960), *The Image of the City*, MIT Press.

Maierborn, C. (1990), Position und Bewegung, zur Semantik lokaler Verben, *Technical Report IWBS, IBM*, Germany, Stuttgart.

Mark, D. (1989), Cognitive Image-Schemata for Geographic Information: Relations to Users Views and GIS Interfaces, *Proceedings of GIS/LIS'89*, Florida: Orlando, 2: 551-560.

Mark, D. (1992), Spatial Metaphors for Human Computer Interaction, in Cowen, D., Bresnahan, P., Corwin, E. (Eds.), *Proceedings of V Spatial Data Handling Symposium*, Charleston: IGU, University of North Carolina:104-112

Mark, D. (1993), Human Spatial Cognition, in Medyckyj-Scott, D., Hearnshaw, H. (Eds.), *Human Factors in Geographical Information Systems*, London: Belhaven Press: 51-60.

Mark, D. (1993), Toward a Theoretical Framework for Geographic Entity Types, in Frank, A.U., Campari, I. (Eds.), *Spatial Information Theory. Theoretical Basis for GIS*, Lecture Notes in Computer Science, Vol. 716, Heidelberg-Berlin: Springer Verlag: 270-283.

Mark, D., Frank, A.U. (Eds.) (1991),*Cognitive and Linguistic Aspects of Geographic Space*, Dordrecht: Kluwer Academic.

Mark, D., Frank, A.U. (1994), Experiential and Formal Models of Geographic Space, *Environment and Planning B*. In press.

Mark, D., Gould, M.D., Nunes, J. (1989), Spatial Language and Geographic Information Systems: Cross Linguistic Issues, in *II Conferencia Latino-*

Amricana Sobre la Tecnologia de los Systemas de Informacion Geografica, Merida: Universidad de los Andes: 105-130.

Mark, D., Svorou, S. (1987), Spatial Terms and Spatial Concepts: Geographic, Cognitive, and Linguistic Perspectives, in *IGIS Symposium: The Research Agenda*, Arlington.

Mark, D., McGranagham, M.D., Gould, M.D., Svorou, R., Egenhofer, M.J., Kuhn, W. (1989), *Languages of Spatial Relations: Working Bibliography for NCGIA Research Initiative* 2. National Center For Geographical Information and Analysis, Santa Barbara.

Marvis, C.B., Rosch, E. (1981), Categorization of Natural Objects, *Annual Review of Psychology*, 32: 252-283.

Medyckyj-Scott, D., Hearnshaw, H. (1993) (Eds.), *Human Factors in Geographical Information Systems*, London: Belhaven.

Monk, A.B., Nardi, B., Gilbert, N., Mantei, M., McCharty, J. (1993), Mixing oil and water? Ethnography versus experimental psychology in the study of computer-mediated communication, *INTERCHI'93, ACM SICGHI Bulletin*, April: 3-6.

Montello, D. (1993), Scales and Multiple Psychologies of Space, in Frank, A.U., Campari, I. (Eds), *Spatial Information Theory: Theoretical Basis for GIS*, Lecture Notes in Computer Science, Vol. 716, Heidelberg-Berlin: Springer Verlag: 312-321.

Neisser, U. (1986), The Sense of Where You are: Function of the Spatial Module, in Ellen, P., Thinus-Blanc, C. (Eds.), *Cognitive Processes in Animals and Man* , Dordrecht: Kluwer: 293-310.

Norberg-Schultz, C. (1979), *Genius Loci. Paesaggio, Ambiente e Architettura*, Milan: Mondadori.

Nyerges, T. (1993), How do People Use Geographical Information Systems?, in Medyckyj-Scott, D., Hearnshaw, H.M. (Eds.), *Human Factor in Geographical Information Systems*, London: Belhaven: 37-50

Pederson, E. (1993), Geographic and Manipulable Space in Two Tamil Linguistic Systems, in Frank, A.U., Campari, I. (Eds.), *Spatial Information Theory. Theoretical Basis for GIS*, Lecture Notes in Computer Science, Vol. 716, Heidelberg-Berlin: Springer Verlag: 294-311.

Putman, H. (1975), *Mind, Language and Reality*, Cambridge: Cambridge University Press.

Rosch, E. (1973), On the Internal Structure of Perceptual and Semantic Categories, in Moore, T. (Ed.), *Cognitive Development of the Acquisition of Language*, Academic Press.

Rosch, E. (1978), Principles of Categorization, in Rosch, E., Lloyd, B.B. (Eds.), *Cognition and Categorization*, Lawrence Erlbaum.

Svorou, S. (1988), The Experiential Basis of the Grammar of Space: Evidence from the Languages of the World, *Ph.D. Dissertation*, Department of Linguistics, State University of New York at Buffalo.

Talmy, L. (1983), How Language Structures Space, in Pick, H.L., Acredolo, L. (Eds.), *Spatial Orientation. Theory, Research and Application*, New York - London: Plenum Press.

Talmy, L. (1993), How Grammar Structures Concepts, *XVI Wittgenstein Konferenz*, Communication, Austria: Kirchberg.

Tversky, B. , Hemenway, K. (1983), Categories of Environmental Scenes, in *Cognitive Psychology*, 15, pp.1-29.

Tversky, B. (1991), Spatial Mental Models, *The Psychology of Learning and Motivation*, 27:109-145.

Varela, F., Thompson, E., Rosch, E. (1991), *The Embodied Mind. Cognitive Science and Human Experience*, Cambridge: MIT Press.

Walsh, D.A., Krauss, I.K., Regnier, V.A. (1981), Spatial Ability, Environmental Knowledge and Environmental Use: The Elderly, in Liben, L.S., Patterson, A.H., Newcombe, N. (Eds.), *Spatial Representation and Behavior Across the Life-Span*, New York: Academic Press.

Wienold, G., Schwarze, C., (1990), Lexical Structure and the Description of Motion Events in Japanese, Korean, Italian and French, *Arbeit papier*, Fachgruppe Sprachwissenschaft der Universitaet Konstanz.

Winograd, T., Flores, F. (1986), *Understanding Computer and Cognition*, Ablex.

Wunderlich, D., Herweg, M. (1990), Lokale und Direktionale, in von Stechow, A., Wunderlich, D. (Eds.), *Handbuch der Semantik*, Berlin: de Gruyter..

Zubin, D. (1989), A Model for Scale Differentiation of Spatially Distributed Percepts, in Mark, D., Frank, A.U., Egenhofer, M.J., Freundschuh, S., McGranagham, M., White, R.M., *Language of Spatial Relations: Initiative Two Specialist Meeting Report*, NCGIA Technical Paper 89-2.