Theoretical Analyses on How Human Cognition Is Related to Spatial Metaphor^{*}

Pan Hu

School of Foreign Language, Nanjing Normal University, Nanjing, 210097, China

Abstract—Cognitive structures and processes are part of human mind, which emerges from a brain and nervous system inside of a body that exists in a social and physical world. This article deals with the theories on human cognition and spatial metaphor, centering around their close relation on the basis of the understanding of spatial world, cognitive maps, spatial learning and development, navigation. Furthermore, the cognitive imageries of spatial metaphor is demonstrated in figures. With the knowledge of the spatial cognition of the world, five cognitive natures of spatial metaphor which are non-arbitrary, creativity, systematicity, multidimentinality and sociality are discussed.

Index Terms-human cognition, spatial world, imagery, spatial metaphor

I. INTRODUCTION

Aristotle (1954) defines metaphor as "the application of an alien name by transference either from genus to species, or from species to genus, or from species to species, or by analogy, that or, proposition". Aristotle's theory on metaphors, to an abstract extent, has influenced experts and scholars for centuries. Lakoff (1980) classifies metaphors into three categories in his famous book Metaphors We Live By: Structural Metaphor, Ontological Metaphor and Spatial Metaphor. A spatial metaphor, also called orientational metaphor, is a metaphor in which concepts are spatially related to each other, as in the following ways: up or down, in or out, front or back, on or off, deep or shallow, central or peripheral and so on. One may talk and interact easily with people in the same virtual room, and may use other means to communicate with people in other locations. Spatial concepts make use of human beings' capabilities to understand quite complex relationships between objects and ideas. Spatial representations are used frequently to convey one or more attributes of the information objects to the user: sorting, grouping and so forth. When users move, use or create objects in space they communicate some relationship either to the system, to some other users or to themselves. The primary advantage of space is that there is more "room" to put objects in and that not the whole space is always "in front of the user". Objects can be moved closer or farther away and the metaphors of the room, the house or the city provide container metaphors for objects that are easy to understand. This type of space is therefore useful to organize larger collections of objects. The main advantage of spatial user interfaces based on real life metaphor is in the ability to communicate a spatial relationship easily to other users. Indeed people are used to navigate in real life spatial environments based on very vague descriptions and facts. They are also generally used to memorize relationships of objects in spatial terms. People might communicate about the location of documents even more naturally and will see how this feature is relevant. Why do people spontaneously use spatial metaphor in their daily life? How does the spatial world where people live in affect people's thinking and speaking? In the rest part of the article, the analyses will be displayed and the answers to those questions will be provided.

II. HUMAN COGNITION AND SPATIAL WORLD

According to human's cognition, the world consists of two great parts. The first part consists of the entities such as objects, events, processes, and the other part is the background environment of the study of cognition: its acquisition, storage and retrieval, manipulation, and use by humans and other intelligent creatures. In a word, the world is composed by the concrete part and abstract part. Human cognition of spatial world is to understand the spatial relations and systems in the world by using the elements of cognition including sensation and perception, thinking, imagery, reasoning and problem-solving, memory, learning, and language. Both cognitive structures and process are belonging to the mind, which originate from the brain and nervous system inside a body that exists in a social and physical world. Spatial cognition is involved in human's finding and understanding of the spatial properties of the world such as location, size, distance, direction, shape, pattern, movement, and inter-object relations.

A. About Spatial World

The two terms *sensation* and *perception* seem the same but in fact there is a subtle difference between them. A person will give a first response to the stimulation from various forces in the world and this response made by the nervous

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system is called sensation. A person senses the world around him by some concrete sensing actions including vision, hearing, smelling, tasting, pressure and texture, temperature, limb position and movement, and physical senses such as gravity and body acceleration. So we can say sensing is the first action taken by a person to learn the objective world. Perception is the active acquisition or cognitive concepts of knowledge about the self and the world obtained by human beings through the senses; in other words, perception is the result of sensing the world. By the methods of sensing and perceiving, human beings get an overall understanding of the world and induced the characteristics of the perceived world as we take different stands to observe the world and the world perceived from several points-of-view, and all of these perspectives are the accesses to the whole world; there is repeated information in the world that means an object or phenomenon may have more than one representations in the world and the repeated information can either help or hinder our understanding of the world; persistence of the quality of objects, events, and background maintain what they originally are even as observing conditions vary; human beings tend to find out meaningful, familiar objects and events to observe and explain and neglect those without meaning and observing value.

B. Cognitive Maps

Cognitive Maps, also called "mental maps" are internal representations of the world and its spatial properties stored in memory. One of the reasons why human beings are more advanced than other animals is that cognitive maps are the proper feature belonging to human beings and shared among groups. Different from a cartographic map in the head, cognitive maps have some natures of their own. First, cognitive maps cannot be observed from a constant perspective and considered as a unitary representation because it is not completely integrated. They consist of discrete pieces and hierarchically organized pieces (Piaget & Inhelder 1967). Landmarks, routes and regions are always employed to describe spatial metaphor and these pieces are determined by physical, perceptual, or conceptual boundaries. Also it is necessary to pay attention to the multiple levels of pieces differing in status, relation of containment between levels, pieces within a level not completely connected, hierarchies revealed by patterns of errors or times to respond to questions about and also the relative locations of places within and between pieces. In addition, spatial information in spatial metaphor cannot well be modeled by metric geometries and the emotional associations or connotative meaning should be found out.

Second, what we see or read may not be correspondent to the cognition in the mind. That is to say there are distortions in cognitive maps. From the distortions and after the relative comparison between the distortions and the accuracy of spatial knowledge, we can employ the following methods to eliminate the distortions of cognition. The first method is finding out the internal correspondence to physical measurement. The second is finding out whether the correspondence is the default idea of most people and the third is realizing the applications of the distortions in our daily behaviors. Here are some examples:

1. Two objects are aligned geographically

ST1: South America is thought to be due south of North America when it is actually southeast.

2. Intersections and barriers make the actual distance between places seem larger.

- ST2: Over a fence and across a children's playground, you can get to the post office which is next to my house.
- 3. Turns are neglected sometimes and curve is considered straight.
- ST3: The leave flied to the sky.

C. Spatial Learning and Development

Learning and development are both changes in human's cognition or behavior that results from practice or experience. The difference is that the former is permanent and the latter is a systematic change in the content and process of cognition over time, from the children's learning, imitation, maturation and growth to an adult. Spatial knowledge is acquired from direct sensorimotor experience, maps, models, photos and drawings, movies and videos, verbal and written language, virtual spaces, etc. Child psychologist Piaget is known for a qualitative "stage theory" of cognitive development of children. He pointed out that a person's cognition changes from concrete sensorimotor space in infancy to abstract spatial reasoning in adolescence (Piaget & Inhelder 1967). The acquisition of the world of any one is from ego-centric to allocentric. That means he learns himself first and then understands the surroundings. The information obtained from the environment has to be processed in the human's mind and it provides an alternative theory of continuous and quantitative development. This process is called frame of reference by Piaget (1967).

We can conclude from Piagetian theory that landmark knowledge is a unique pattern of perceptual events that identify a place; with the landmark decided, the route can be explored which means the sensorimotor routines that connect ordered sequences of landmarks; sometimes we will reach the goal directly or indirectly by detouring, shortcutting and creative navigation.

D. Metaphorical Navigation

Navigation is a very abstract concept in human's mind and it is a coordinated and goal-directed route formed in the brain from the experience. Metaphorical navigation helps us to follow a route we have selected unconsciously to the destination we need to go. It consists of two components: locomotion and wayfinding. Locomotion is originally a term in physics indicating the movement of the object. But in the metaphorical cognition, it refers to the guidance through space in response to local sensorimotor information in immediate surrounds. To really understand the concept, we will

find support surfaces, avoid obstacles and barriers, follow beacons, move through openings and choose one of the modes: crawling, walking, bikes, cars, planes, etc. this is just a vivid comparison. Its real indication is before we understand a spatial metaphor, we need to find the possible routes or methods to analyze it and be immune to the other disturbing elements. As for wayfinding, it is planning and decision-making in response to nonlocal information, undertaken to reach goal. And to take this point in, we should figure out route-choice, destination scheduling and orientation to non-perceptible features, giving directions.

Navigation is a term used in the voyage but now it is used in the understanding of spatial metaphor. There are two fundamental processes of orientation during navigation. First, we base the cognition on the landmark to reach the goal; second, if there is no clear landmark, we can firstly observe the integrating information that is to say the context in which the spatial metaphor is located. Navigation is carried out via skills that vary in their demands on attentional capacity and relatively automatic skills do not demand much attention, such as locomotion in "normal" environments, following familiar routes to work, etc. The third, when seeing the clues of the author's emphasis, we demand focused attention on the skills used by him and this is also the feature of navigation on sea.

III. IMAGERY OF SPATIAL METAPHOR

The term imagery belongs to cognitive scope, referring to the representation of sense perceptions in brain. Imagery can result in the situations and matters one has experienced sometimes appear in the brain. However not everything can leave behind all the details including features, frames and so on in the human's brains for a long time, usually human will forget a great part of these details after a while. So it is actually a frame without details which can be called abstract analogy that stay in the memory. Psychological research shows that the representation of information and meaning does not entirely depend on abstract symbols and concrete descriptions but is greatly influenced by imagery. Imagery can be kept for long in memory and altered and deformed in mental space so as to make thinking, reasoning and expressing easier. Image schema proposed by Lakoff and Johnson (1980) lays emphasis on the physical experience and schemic functions of imagery, but imagery, also called sensory imagery is a similar sense without the stimulus of outside.

A. Salience

The people's understandings of a matter vary when different focuses are chosen. As we describing X is similar to Y, we can say "X resembles Y" or "Y resembles X". in spite of the same structures, the two sentences differ from each other on semantics. The former implies "X" is the focus and "Y" the background, i.e. X is the salience. On the contrary, in the latter sentence "Y" is the salience. Here is another pair of examples,

X is above Y.

Y is below X.

A different salience may lead to different semantics. People's cognition can influence semantic structure and utterance. The same situation may remain different imageries in the brain because of different observing angles and methods.

ST4: A cup is on the table.

ST5: On the table is a cup.

The two sentences, although having totally same elements, select different salience. ST1 emphasizes *a cup* and ST2 *on the table*.

B. Base and Profile

The formation of imagery needs a base and a profile. Profile is indeed the meaning of the word. Each imagery imposes a profile onto a base which is the background or cognitive domain of predication (meaning) and a profile is the focus or salience designated by the expression. For example, when *nephew* is discussed, it is put into a base-kinship network. Naturally *nephew* is a profile as the following Fig 1.



Figure 1. Base and profile of *nephew*

As for the base-profile relationship in spatial metaphor, TR (trajector) and LM (landmark) should be counted in. Spatial verbs involve a time process of an object. An object's movement contains both space and time domains so the concept of verbs may also be represented as dynamic imageries. For instance, the meaning of come develops with time (t) and trajectory is approaching landmark. Fig 2, 3, 4, 5 share same parameters as shown below.

s=space

t=time

○ : TR (trajector) =he

: LM (landmark) =Shanghai ST6: He will come to Shanghai.



Figure 2. Dynamic imagery of ST6

ST7: He is in Shanghai.

ST8: He is away from Shanghai.



Figure 3. Base-profile relationship of ST7



Figure 4. Base-profile relationship of ST8

ST9: He is gone.



Figure5. Dynamic imagery of ST9

ST7 and ST8 are only the results of movements and ST9 is a base-profile structure. Besides the elements needed to describe meanings, the causes of different images in the same situation mainly rely on another parameter-selection.

C. Selection

Selection means selecting the aspects to be observed and expressed. Language users cannot express all the aspects of a thing but select one aspect that interests him most. And each profile belongs to one cognitive domain.

ST10: Could you please lift the suitcase up to the fourth floor for me? (space domain)

ST11: Up to summer vacation Chinese elementary students have been busy. (time domain)

IV. COGNITIVE NATURES OF SPATIAL METAPHOR

With the knowledge of how human cognition is related to the spatial world, it is not hard to understand the cognitive bases or physical natures of spatial metaphor. Based on the investigation into the words and sentences which contain spatial metaphor, some characteristics are observed to be applicable both to English and Chinese. In this chapter, these natures will be analyzed in detail.

A. Non-arbitrary

The embodied motivation for metaphor provides a natural, non-arbitrary reason for why people regularly construct the asymmetrical metaphorical mappings they do, to better understand many abstract concepts. People do not necessarily learn to form metaphorical representations only from their embodied experience, because their expression with the language itself will help them to tacitly infer, via generalization, many metaphorical concepts. But it is clear that there are important links between people's recurring bodily experiences, their metaphorical projections of these image schemas to better structure many abstract concepts, and the language used to talk about these concepts.

B. Creativity

As a branch of linguistics, spatial metaphor is also characterized by creativity. The capability of operating linguistic mechanism can make human beings create innumerable expressions and meanings from limited regulations and linguistic elements. Meanwhile metaphors play a key role in people's experience; as a result, as human beings have mentality, they are equipped with the organism that can interpret the past in their memory, the future they will participate in and the world they encounter. Two approaches have been recognized to make spatial metaphor creative, one of which is the associative meanings of vehicles. The spatial words "up" and "down" have more than two or three variants, as is shown in TABLE 1.

TABLE 1		
VARIANTS OF "UP" AND "DOWN"		
WORDS	VARIANTS	
up	upright, upstanding, rise, high	
down	low, low-down, decline, stoop, abyss, fall	

The variants of "up' and "down" are all derived from the general concept "GOOD IS UP" and "BAD IS DOWN". In addition, experience shows that happiness is closely linked to smile. Smile is an action that mouth stretches to the directions of ears, which bases the spatial metaphor "Happy is wide" and "I am felling expansive." Finally the presentation of the creativity of spatial metaphor in science is worthy of discussion. Many scientific concepts are based on spatial metaphor in that the world either real or non-real is named, recognized and interpreted by metaphors. For instance, the word "high" in "high-energy particles" is based on the structural metaphor "MORE IS UP" and "high" in "high-level function" is based on "RATIONAL IS UP" and "low" in "low-level phonology" is based on "MUNDANE REALITY IS DOWN". Therefore spatial metaphor is applied to interpreting some abstract concepts unconsciously by human beings. As a result, it is not only a linguistic property but a mental pattern which always influences people's thought and action.

C. Systematicity

Systematicity of spatial metaphor should be subdivided into internal and external systems. From a micro viewpoint, each spatial metaphor has an internal system. For example, "I'm feeling up" means "I'm feeling happy". Then which word should be used if "I became happier" needs to be expressed? Among the dynamic vertical spatial words, "rise" not "fall" is selected to match this meaning because there is a logic system in people's mind, as shown in Fig.1



The system is logic and congruent and not separated and arbitrary. So "My spirits *rose*" can indicate "I became happier".

D. Multidimensionality

In the preceding illustrations, vertical spatial metaphor is frequently employed. Actually the same topic in spatial metaphor can be expressed by several vehicles by use of different spatial concepts. As more intelligent animals, human beings can observe an object and a kind of phenomena from more than one dimension such as up-down, left-right, front-back and out-in. Besides, spatial metaphor, as a metaphoric concept, uses a spatial concept to describe analogically another concept but not a direct projection to the objective world. It is a refraction because the description contains many subjective elements after the mental processing. As a result, the forms of spatial metaphor vary from the angles people subjectively choose. But the subjective choices cannot be arbitrary since topics and vehicles have to share similarities at least in one aspect. Obviously creativity of spatial metaphor provides conditions for multidimensionality. In short, the multidimensionality of the objective world provides multi-angles with premise and conditions while the multi-angles present the multidimensionality of the objective world. So many topics in everyday life are the familiar abstract concepts for people and closely related to people's lives such as happiness and anger. For these concepts it is hard to tell their exact meaning, but it can be illustrated from different angles.

1. Vertical ANGER IS UP.

CALM IS DOWM.

"Anger" is a kind of cognition and develops to an emotion. When anger increases, the fluid in bodies will rise and create pressure and then explode. This kind of spatial metaphor is based on the physical and mental experience. It can also be put as a metonymy theory, that is to say, it uses a physical state to represent the emotion.

She blew up at me. His pent-up anger welled up. 2. Inclusive ANGER IS OUT. CALM IS IN. As mentioned in the preceding

As mentioned in the preceding part, the conceptual metaphor of "anger" is often described as "Anger is heated fluid in a container". So human bodies are always regarded as containers in which all kinds of emotions constantly change their states.

She couldn't contain her anger. I gave vent to my anger. Smoke was pouring out of his ears. That really set me off.

To sum up, the abstract concept of "anger" can be expressed by both "up" and by "out". Apparently each type of spatial metaphor has its own motivation and emphasis, which happens to make an overall cognitive system.

E. Sociality

For one aspect language is a social phenomenon. Spatial metaphors are also characterized by sociality because they are based on the same physical organism, the same cognition and the similar acceptable mentality. Although thousands

of languages coexist in the world, many spatial metaphors are quite similar across languages. Here are some examples between English and Chinese, as is shown in TABLE 2.

 TABLE 2

 Similarities of English and Chinese spatial metaphor

English	Chinese	
Set up one's bristle	怒发冲冠	
Go up in the air	怒气冲天	
Smoke poured out of his ears.	七窍生烟	
Spirits sink.	意志消沉	

Different cultures determine the variations among spatial metaphors. Some people are greatly influenced by their traditional concept of "up-down". But some others pay more attention to "in-out". Similarly "active is up" and "passive is down" are acceptable in one culture but may not in another one.

V. CONCLUSION

In this article, how human cognition is related to spatial metaphor is studied theoretically. Before their relation is revealed, the combination of human cognition with the objective world is discussed. People sense and perceive the world from locational perspective, redundancy of information, constancy and meaningfulness. Afterwards, the world leaves behind mental maps (internal representations of the world and its spatial properties) in the mind, which make human beings get to know spatial knowledge and cognitive development with the help of navigation. With the help of figures, some sentences are analyzed in terms of their image schema, which vividly explains how human cognition affects spatial metaphor. Then the cognitive bases of some typical spatial words and their application are probed into in this article. By using some figures and tables, the five natures of spatial metaphor—non-arbitrary, creativity, systematicity, multidimentinality and sociality are generalized.

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Pan Hu was born in Si Chuan, China in 1978. She received her M.A. degree in linguistics from Southeast University, China in 2003. She is currently a lecturer in Foreign Language School, Nanjing Normal University, Nanjing, China. Her research interests include teaching methodology, spatial metaphor and psycholinguistics.