

Chapter 2

Basic Forms of Human Thinking

2.1 Diverse Classification of Basic Forms of Human Thinking

In terms of forms of thinking, diverse categorizations were proposed according to different principles.^{1,2} For example, in terms of abstraction of contents, thinking can be divided into concrete imagery thinking and abstract logical thinking; according to the intelligence of thought, there may be reproductive thinking and creative thinking; according to thinking process in terms of thinking direction, it can be divided into divergent thinking (i.e., divergent thinking, reverse thinking and multi-dimensional thinking) and convergent thinking (i.e., focused thinking, convergent thinking and positive thinking); according to thinking depth, it could be divided into conscious thinking and subconscious thinking and so forth. Each of the above principles of classification has its own rationality, and it's indispensable to study different aspects of thinking. However, thinking is not a general category. In order to seek survival and development in the struggle with the nature, the humans developed this unique function of the brain, after million years of evolution process. Therefore, if we consider the classification of thinking from basic forms of human thinking, there would be only one principle of classification—principle of epistemology, following the law of human understanding of motion and change; that is, to recognize the thinking forms from philosophical point of view. Unfortunately, majority of psychologists and philosophers seem to have not been aware of this. Hence, we shall turn to the basic forms of human thinking—views from academia, domestic and foreign.

On the classification of thinking, the first view believes that the basic form of human thinking is abstract-logic thinking, while imagery thinking and other forms of thinking are secondary. Some went even further to deny the existence of imagery

¹Zhu et al. (1991).

²Dong (1993).

thinking. For example, as a considerable influential course book for China's liberal arts colleges, *Psychology of Thinking* defines the task of thinking psychology as such³: "it's trying to answer the main question: how do people think? If thinking concerns with concept, judgment and inference, then psychology of thinking research agenda would be the process of concept, judgment, and reasoning, which would not be the contents that correct concept and judgment follow; instead focusing on "*how does a concept form, how do people master them, how do people make judgments, how to make an inference, how do people solve problems and as a process, how does thinking occur, change, and develop with its laws?*" Obviously, the author of the book takes thinking as "the use of the concept, the process of reasoning"; that is, thinking is considered only as logical thinking. As a matter of fact, in this book of teaching thinking, one finds no mention of imagery thinking in more than 400 pages. Some psychological monographs, though admitting the existence of imagery thinking, still try to play down the role of imagery thinking. For example Yang Yuhui,⁴ in *Unravel the mystery of consciousness—working principles and mechanism of the brain*, points out "Imagery thinking can only be achieved by accepting and grabbing a variety of specific, special things here and now, which cannot be separated from particular things, or not beyond understanding of specific things now, not moving from the particular to the general, not generalizing from now to the past and future, nor can it go from here to there. In the end, the nature and law of things cannot be mastered". Imagery thinking is "just at the primary stage of conceptual thinking". This view, while recognizing imagery thinking, still considers it only as a primary stage of logical thinking, denying that imagery thinking is also one of the basic forms of human thinking. Therefore, this view can be placed in the first group of thinking classification.

The second group of thinking classification holds that basic form of human thinking is not abstract-logical thinking, but visual thinking. The representative who holds this view is professor Rudolf Arnheim from Harvard University, who is founder of international scholar of aesthetics and art psychology. He deems that the basic material of thinking is imagery, rather than what people often say the concept or language.⁵ "Language is only an auxiliary to the main material (imagery), and a clear imagery can represent the relationship between objects better". He also believes that, "grasp the overall structural features of things is the basis for all primary cognitive activities and all kinds of perceptions".⁶ The most important perception is visual perception, because visual perception is a clear media that can provide a wealth of information about things in the outside world. Visual perception can be "readily used by consciousness". Arnheim proved that, based on a large number of facts, visual perception itself has cognitive ability, comprehension ability and the ability of problem-solving, which has thinking function, and thus visual

³Wang (1992).

⁴Yang (1996).

⁵Arnheim (1969).

⁶Arnheim (1969).

perception is of not a lower level of thinking. On the contrary, it's one of the most basic forms of human thinking. On the basis of this understanding, Arnheim put forward the famous concept "visual thinking" for the first time, and used it as the title of the book written many years ago, studying human thought. From this view of thinking, he differs with the division of imagery thinking and abstract thinking; just as Mr. Teng Shouyao points out⁷: "In his view when people see an image (imagery perception and mental imagery), abstract activities begin; and when people think about a problem, there's a specific image as the starting point and foundation. According to common sense, thinking is thinking because it's proceeded through concepts of general nature; imagery is imagery, because it's concrete and specific. If this specific image comes into thinking, it will interfere with the general nature of concepts". As mentioned above, the basic material of thinking is imagery, in other words, people think on the basis of a specific image. Therefore, in Arnheim's opinion, such thinking is neither pure imagery, nor pure abstract, but visual thinking.

The third view holds that abstract-logical thinking and imagery thinking are basic forms of human thinking. However, before three years of age, children use mainly "intuitive action thinking" (or "action thinking"),^{8,9} which is a more popular view among social psychologists and the lay population. This view is basically the same with the first view of abstract-logical thinking, though both maintain that thinking is "a process of using concept to judge and reason", while the abstract-logical thinking relies on action and imagery, the main materials of thinking is concept.¹⁰ Abstract (logical) thinking subdivides into formal-logical thinking and dialectic-logical thinking: the former is deterministic in nature in contrast with the self-contradictory thinking process of dialectic-logical thinking; the latter is flexible and emphasizes the things of inherent contradictions. The two views are different, yet interrelated. Dialectic-logical thinking, gradually developed on the basis of formal-logical thinking, belongs to the advanced stage of abstract-logical thinking. These two are not in opposition to but complement to each other. About imagery thinking, the third view holds that the main material of thinking is representation or imagery, with two different stages, concrete imagery thinking and general imagery thinking.

The fourth point of view believes that in addition to imagery and logical thinking, the basic forms of human thinking should also include creative thinking.^{11,12} The spokesperson of this view is Professor Qian Xuesen, a famous scientist in China. Here it should be noted that Professor Qian published articles in the early and mid 1980s, advocated the division of thinking into intuitive-imagery thinking,

⁷Teng (1987).

⁸Zhu and Lin (1991).

⁹Ye and Zhu (1992).

¹⁰Zhu and Lin (1991).

¹¹Qian (1986).

¹²Yang (1997).

abstract-logical thinking and inspiration-insight thinking as three basic forms of human thinking.¹³ Later after more study and discussion with an academician namely Dai Ruwei, his ideas developed. The original division was modified. In a letter to Professor Yang Chunding in June 28, 1995, Professor Qian pointed out that “the field of thinking focuses on the process and product of thinking, regardless of the process in the human brain, so I prefer imagery-intuitive and inspiration-insight thinking. The imagery and inspiration/insight are the same in thinking images in different brain states. In addition, creation needs imagery thinking and then verifies the results with logical argument. This is dialectical unity of the two types of thinking, a higher level of thinking. It should be named creative thinking. This is the flower of wisdom! So thinking should be summed up as logical thinking, imagery thinking and creative thinking. Social thinking and specific thinking, and so on which were mentioned above, belong to the three basic types of thinking, because they are just under different brain states.”¹⁴

As can be seen from the introduction above, the first view is to stress and highlight abstract-logical thinking, the second is to stress and highlight visual thinking. Arnheim disagreed about the demarcation between imagery thinking and abstract thinking. He was not too willing to use the two terms as well. However, as long as we carefully read his masterpieces, it's not difficult to find that visual thinking actually refers to visual imagery as the main materials of thinking, so in essence the second view emphasizes and highlights the thinking in imagery. Arnheim, also, through the concept of visual thinking, greatly expanded the connotations of imagery thinking both in depth and breadth. The third view argues that “one cannot say which kind of thinking is good or not. Scientists, philosophers, writers, and engineers all need to have abstract thinking ability, but also need to have the ability of imagery thinking”.¹⁵ In other words, the third view avoids leaning toward either imagery thinking or abstract thinking. The fourth view is basically the same as the third view, adding creative thinking apart from imagery thinking and logical thinking. Creative thinking was put forward in the field of psychology years ago, and has been studied carefully. As early as in 1945, Wallas' proposed the famous “four-stage model” of creative thinking process; in 1960s, Guilford carefully analyzed, summarized creative thinking, and produced great influence. However, in the past, creative thinking has always been considered as a distinguished feature of scientists, inventors and artists alone, and most people are not qualified for possessing it. Therefore, in the past, creative thinking was mostly used as a special phenomenon to explore while studying the unique thinking process of gifted children in minority. In 60's and 70's, the United States conducted creative thinking experiments in a few schools, such as Myers and Torrance creativity gymnastics teaching procedures and Field Husen creative thinking teaching experiments, but these experiments are basically under the guidance of Guilford's

¹³Qian (1984).

¹⁴Yang (1997).

¹⁵Zhu and Lin (1991)”.

theoretical framework and the so-called creative thinking experiments were closely the same as divergent thinking (this is the core idea of Guilford's theory). In fact, divergent thinking is only an element of creative thinking structure, which cannot reflect the profound connotation of the whole creative thinking process. At the end of 70's, more and more people began to notice this issue. Therefore, taking divergent thinking as the general form of thinking is a different kettle of fish from taking creative thinking as the common form of thinking for ordinary people. Making creative thinking come down the unattainable mysterious altar, believing that it is possible for more people to acquire, and making common people possess this thinking, which is a new idea appearing after the mid-80 s. Professor Qian made an indelible contribution as he played a big role in changing people's understanding of this issue.

2.2 New Thoughts on the Basic Forms of Human Thinking

Some major views on the basic forms of human thinking at home and abroad were briefly introduced above. Although some of views are obviously biased, such as the first and second, yet in general, these views have certain basis and rationality, and some even have great impact (such as the third), while others are quite innovative, such as the fourth. But as noted earlier, these views basically ignore a fundamental issue: they all failed to understand the division of basic forms of human thinking from philosophy or according to principles of epistemology (only the fourth view originally tried to explore basic forms of human thinking, but from many published articles one failed to see concrete exposition about it). They just consider the thinking processes or thinking contents from the specific psychology. Thus the conclusions may have some scientific and practical value, yet lack theoretical generalization efforts; as a result, its universal significance and practice guiding role will be greatly reduced; and reasonable explanations cannot be made for important thinking process and phenomenon. The theory faces an awkward situation.

Here we try to analyze the issues of basic forms of human thinking from epistemology of Marx's theory.

On thinking, philosophers and psychologists believe that the brain's unique function evolved over a long period of time^{16,17} and they define it as "[thinking] made by humans to generalize and indirectly reflect physical world, the essence of things, and inherent relation among things".¹⁸

In order to survive and develop, humans must struggle with nature, and understand and master the basic characteristics of things in the physical world and basic laws of mutual relation among things. In order to cope with nature, further

¹⁶Zhu and Lin (1991).

¹⁷Ai (1978).

¹⁸Zhu and Lin (1991).

transform the physical world and to reach the expected purpose, human thinking becomes indispensable intellectual function. According to dialectical materialist view of philosophy, the physical world is matter; and matter is always in motion and change; movement is basic attributes of matter, and space and time is the moving material form; specific things are just matter of all different forms of nature and society.¹⁹ Therefore, to comprehend and grapple essential rules of things in the physical world and their mutual relation, one only needs to study in-depth and analyze of the form and feature of different motion states of all things, namely the essential attributes. The movement of things, as Mao Zedong points out, has “two states—relatively static state and significant changing state”. The relatively static state is also called “the state of being”, and state of significant changing is usually “the state of motion”. So we shall, in terms of nature of things, attend to the distinction between nature of two different states of motion; namely, the nature of current state (relative static state) and nature of motion state (marked by changes).

Since matter exists in space and time, it could be concluded that no matter in the universe moves out of space and time. The inseparability of matter from space and time is not only the view of dialectical materialism, but also scientifically proven by Einstein’s special relativity and general relativity. So when we talk about the existence of a thing, first of all, we allocate where it exists, in what form, involving the form of the thing in space and time, as well as the spatial position of one thing in relation to other things, their structural features in combination or arrangement. This is what is referred to as “characteristics of spatial structure”; that is the current state of the thing (relatively the stationary motion state), the essential attributes and regularity of internal link of things. The motion of matters always shows as a process, and the process must have sequence and duration. Therefore, when we consider the movement of things and relation of things we can never leave out time factors; that is to say, we can never leave out sequence and duration. This is a feature of “temporal sequence”, significantly changing state (commonly referred to as dynamic state), i.e., essential attributes and regularity of things in internal relations.

Karl Marx’s epistemology believes that matter is primary, consciousness is secondary. Consciousness is the reflection of the human brain on the existence of physical world.²⁰ The core of Marx’s epistemology is *Reflection Theory*. Thinking is the main content of consciousness, and, of course, is also secondary in nature. The definition of thinking above is based on Reflection Theory. Thinking is generalization and indirect reflection of human brain on laws of the physical world (the nature and inherent relations are the features of dynamic movement of things). Nothing in the universe exists out of time and space, so in order to effectively generalize and indirectly reflect things, thinking, as a secondary process, must be able to adapt to the needs of consciousness, which are primary in nature (the movement of things happens in time and space); that is to say, thinking must meet

¹⁹Li et al. (1995).

²⁰Li et al. (1995).

requirements of things moving in space and time. According to the principle of Marx's epistemology, human thought should have at least two basic forms of reflection.

The first is the form that is able to effectively generalize and reflect spatial-structural features of things; i.e., the status of things (or relatively static state, the essential attributes of things and regularity of internal relations between things).

The second is the form that can effectively generalize and reflect the nature and regularity of internal relations, the time sequence of things (in state of motion, or significantly changing state).

The characteristics of spatial-temporal thinking should be analyzed next, but in order to better understand the problem in this area, we might as well first discuss how to realize the requirements in the definition of thinking proposed earlier, "to generalize and reflect on the nature of things and relation between things" and then necessarily reflect on the dominant positions of logical thinking.

2.3 Reflection on Dominant Forms of Human Thinking

2.3.1 *Formal Structures of Logical Thinking*

Dialectical materialism holds that²¹ the essential attribute of things is the fundamental nature of things, which is determined by the special contradictions inherent in the thing itself. This special contradiction not only specifies the fundamental nature, but also determines the development of things.

Dialectical materialism also believes that²² all things in the physical world do not exist in isolation, but mutually connected and interacted as a unity. Everything in the universe exists as an individual, but also interrelates to each other; everything is a link in the universal connection. Therefore, for the sake of understanding the nature of objective entity (the essence of things), it's necessary to appreciate particularity of things, apart from which it also be necessary to recognize mutual connections between them (i.e., the intrinsic law between things).

The view of dynamic nature and universal connection of things are the most fundamental and core of dialectical materialism. It's the cornerstone of Marx's philosophy. The reason why definition of thinking provides these two aspects: the nature of things (reflecting the movement and change of things) and internal relations (reflecting universal relations of the physical world), is just based on dialectical materialism of the fundamental viewpoint.

In order to generalize and indirectly reflect such two aspects of things: the nature of the things in dynamic motion and interrelations, language has been created (including oral form and written form) as the material of thinking (oral language

²¹Li et al. (1995).

²²Li et al. (1995).

uses sounds as the material, written language uses graphic forms as its material). Based on these materials language gradually developed a system of concepts, judgment and inference, in order to generalize and indirectly reflect the world around us. The reason for “language indirectly reflecting the world” is that this reflection is done indirectly by using “concept”, “judgment”, and “reasoning”, rather than directly on things (just like a camera that reflects). The reason for “language generalizing the word” is that this reflection is not a replication of all attributes of objective things, but the nature of movement of things, and abstraction of the internal links of things (abandoning non-essential attributes). We shall explain the function of concept, judgment and inference below.

The concept is a reflection of the nature of things, particularity of contradiction movement, which is based on analysis and synthesis of various attributes of things, and further, abstracted and generalized from things. It's the gradual understanding of particularity of contradiction movement of a variety of things that humans develop in long-term process of practice. The more extensive and thorough the understanding of things is, the richer and clearer the accumulation of concepts is. The concept is not only the summary of human understanding of the physical world, but also the material of human thinking or the object of human thinking. In thousands of years of civilization progress, mankind has established a huge concept system of different levels, from philosophy, natural sciences, social sciences, the specific subject to daily life, which laid the foundation for the human correctly reflecting the physical world.

Judgment of a certain (or certain type of) thing has a certain attribute, but also to make a decision on whether there's an internal connection between things. The judgment in thinking is made up of several concepts. In order to give details of classification and structure of judgment, it's necessary to know how things relate to each other. As is known, dialectical materialism stresses not only the movement of things and relation between things, but also emphasizes conditions, under which things move and relate; i.e., things always develop and decline under certain conditions; and properties, structures and features of links between things also change under different conditions. All develops in time, in place and under certain conditions. “Time” and “place” (space) is the forms that matters exist. They cannot be separated from motion; and conditions are the premise or external objects of movement, thus its importance equals with time and space. In short, change and link of all things is conditional; condition is absolute. In this sense, general relation theory of dialectical materialism can also be called *conditional theory*.²³ The condition is not only the premise or the external cause of change or movement of things, their mutual connection, but also the effect of the premise or external factors; namely, the results. This builds on our knowledge and informs us of condition-result relations (in most cases, shown as cause-effect relation) is the most common relation of physical world. Generally, mutual relation and interaction between things is condition-result relations in different situations.

²³Li et al. (1995).

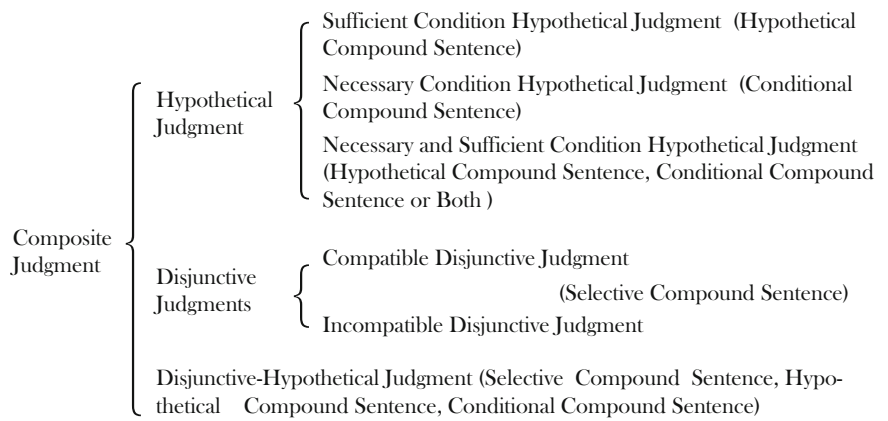


Fig. 2.1 Judgment system

The specific conditions of actual situation are complex and diverse, ever-changing, but according to condition types, one can divide them into three categories: sufficient conditions, necessary conditions, and necessary and sufficient conditions. Besides, conditions related to things can be single individual (singular) or a part of a class (specific), which can also be all of a kind (plural); and conditions corresponding to the same results can be one selected from a number of them. In order to reflect different condition—result situations, the study of logic establishes a set of “judgment system” as shown in Fig. 2.1.

Various hypothetical judgments are specifically designed to respond to different condition-result relations; disjunctive—hypothetical judgment is suitable for two or more alternatives. A variety of forms of complex sentences to achieve the corresponding judgment through language expression is given in the parentheses.

In addition to the above judgment reflecting the rules between interrelated things hypothetical and disjunctive judgments, direct judgment is used to determine whether something has certain properties. Because judgment is of positive and negative nature and can be single, special and universal, there are six types of direct judgment: referred to as single affirmative judgment and single negative judgment, special positive judgment, special negative judgment, universal affirmative judgment and universal negative judgment.

Reasoning is used to make a reflection of more complicated relations and interaction between things. The premise of reasoning can be direct judgment, hypothetical judgment, disjunctive judgments or disjunctive-hypothetical judgment. Therefore, according to the premise used, different reasoning can be classified as direct reasoning, hypothetical reasoning, disjunctive reasoning and disjunctive-hypothetical reasoning respectively.

From the above analysis, it’s obvious that through establishment of language-based system of concepts, judgments and reasoning, it can meet the requirements of making generalization and indirectly reflection of the nature and rules of the internal

connection of things. As to how to define concepts, make judgment and reasoning, it's the area of general logic; it's usually called logical thinking, which is based on language, using concepts, making judgments, and reasoning.

2.3.2 *Limitations of Logical Thinking*

Language (either spoken or written) is the material of logical thinking. Its essence is to use linear-sequence of symbols (sound sequence or graphic sequence) to represent contents of thought (the relationship between things, and the essential attributes of things). Since it's a linear, symbolic sequence, there're issues of time, order and continuity. In other words, to use language-based symbols to conceptualize, to judge, and to reason, it can only be in accordance with the different word symbols in linear order, step by step, to carry out the task. For example, in hypothetical judgment of composite judgment, it normally contains several simple judgments. The conditional parts are called "front parts", while the results parts are called "after parts", in addition to the parts linking front and after parts, there are connectors. The judgment process must necessarily scan sequentially the three parts one after the other (one graph after another, or one sound segment after another), only in this way it may determine whether condition-result relation exists. Obviously, this judgment process should last for a long time, so efficiency is relatively low. The efficiency of reasoning process is lower—due to the involvement of major premise and minor premise and conclusion, and each part contains one or even several judgments. And thinking in accordance with such a step-by-step, sequential scan, time duration will be longer.

In addition to low efficiency, it's difficult to reflect dynamic events and visual scenes with the linear nature of language. Even in one of the simplest, direct judgments (i.e., declarative sentences), the influence of language can be clearly revealed. Susan Lange used a statement as an example, which vividly shows the problem²⁴:

A fact, if it's shown in the form of language, it's subjected to such a distortion, in which the dynamic relationships (or connections) became static relationships. Take 'A kills B' as an example. The scenario described in this statement does involve a sequence of activities between A and B. In the first place A appears, then there's a 'killing' behavior, after which B appears. In fact, A and B appear at the same time, and 'killing' behavior appears at the same time as well. However, due to the fact that language symbols are linear and disconnected in nature, as beads of pearls, they can only appear successively.

Arnheim²⁵ commented on this example, "A rational concept is shown by language in linear order, so what is described is often an intuitive grasp of the situation, and re-structuring of the scene. The statement, "The tree is laden with cherries", is an intuitive image coming from the speaker or the writer about an orchard scene,

²⁴Lange, S (1960). *New interpretation of Philosophy*. Cambridge: Harvard University Press.

²⁵Arnheim (1969).

which evoked the same imagery in the mind of the reader or listener. In the same way, ‘A killed B’ can evoke an imagery of a murder. In these cases, we see that language is actually a bridge between the speaker’s imagery and the recipient’s imagery. Because the medium itself is linear, it cannot but affect the representation of imagery. For example, ‘a simultaneous interaction’ cannot be directly described by words”.

Lessing has a brilliant exposition of this issue in the monographs on poetry and painting. Lessing²⁶ pointed out that “painting, dealing mainly with shapes and color in space, can be used to describe the presence of objects of all kinds in space; or to describe each part of an object appearing at the same time space. As for ‘activities’, they’re carried out in chronological order, it’s only the object of the poem. Painting can indirectly describe ‘activities’ through description of human body. Poems can describe human body indirectly through description of ‘activities’. If poems (including all languages) are not used to describe the ‘activity’, but rather to describe a visual scene, it can only be described by one of the various components of the scene. In this case, the recipient’s mind is often not able to make the sequence of bits and pieces into a representation that is consistent with the original visual imagery”.

Examples cited by Susan Lange and Lessing’s comments show that when the description is a direct use of parts of the scene, the description of the spatial-visual scene will often fail to make the readers re-construct the author’s representation. In other words, logical thinking under this situation is not complete and not true to the space-visual scene. Can this kind of situation be changed to make logical thinking reflect space-vision scene, as is the case with time sequence processing? The answer is affirmative. This is to use the usual method of writers—through a series of events (activities)—to describe the visual scene. That is to say, to some kind of vision, not simply to decompose it into a number of components, but on this basis to further transform the static scene into an activity scene. Because activities are developed according to time sequence, language, on such occasions, can play the role, present local relations between each event with rich details, and use linear features throughout the whole event. As a result, description of the visual scene is transformed into connected frames in a movie (discussion of a point of view, procedures follow similarly); a three-dimensional space of the visual scene, convert to a one-dimensional time axis expanding a series of activities in event sequence.

Obviously, such a conversion is indeed effective, because it really solves the problems proposed by Susan Langer and Lessing et al. Precisely because of this, many psychologists and philosophers overjoyed that logical thinking solved all the problems faced by the human mind, believing that only logical thinking can achieve rational knowledge, and it’s advanced thinking, and imagery thinking can only stay in the perceptual stage of cognition, which is a lower form of thinking. What is more, some went so far as to say that only logical thinking, based on language armed with concepts, is the real human thinking, while the others, based on imagery thinking, are not considered as thinking. Those who strongly advocate “left brain

²⁶Arnheim (1969).

prominence” theory are the representatives. At present, China’s academia of philosophy, psychology, and even the whole society, is still dominated by this view.

We cannot agree with this view. We think that this is over-valuation of logical thinking. As you can see from the analysis above, real and complete realization of visual space scene through logical thinking is not unconditional, but through transforming three-dimensional space to one-dimensional time axis, at the expense of efficiency. It should be realized that such a price is heavy, especially in the requirements of overall grasp of features of spatial structure in a brief moment (such as act on an urgent need according to circumstances), or to make major decisions on the complex relationship between things as soon as possible (such as getting out of hardship or danger in urgent need). In such occasions, the linear order of logical thinking will become powerless. And the spatial structure of thinking, then based on another kind of imagery thinking can play an important role in such occasions, thus making up for the inefficiency of logical thinking. In the following sections, we will discuss this kind of thinking in detail.

2.4 Main Features of Spatial Thinking and Temporal Thinking

In the section “New thinking on human basic thinking classification”, we inferred that the human mind shall at least have two forms of thinking, spatial and temporal, according to the dialectical materialistic epistemology of space and time. The former is used to generalize and reflect spatial-structural features, and the latter is a generalization of time sequence, characteristic of movement of things. Below we shall, first of all, analyze the main features of these two kinds of thinking.

Spatial thinking generalizes and indirectly reflects spatial-structural features of things (that is, the features of spatial location, and existential form and nature as well as the relations of things and association, combination or sequence of things in space). Obviously, this form of thinking is to grasp things as a whole in space, their existence, form, nature, and basic attributes in space (this is done mainly by various imagery, which reflect the attributes of things, especially spatial-visual imagery), and also to grasp the interrelation between things, their spatial location and structural relations (this is done mainly by the visual imagery which reflects the spatial-structural relation between things). Due to characteristics of the two (the basic attributes of things and the interrelation between things i.e., structural relation between things), which should be grasped through visual-spatial imagery (or we can say they should be grasped mainly through visual-spatial imagery), and visual-spatial imagery is integral and structural. The features of these two aspects are known for the characteristics of spatial structure. Reflecting the features of spatial structure is the most basic feature of spatial thinking. In order to emphasize this feature, we can also name this form of thinking as “spatial-structural thinking” or simply as “structural thinking”. As a matter of fact, this “spatial-structural features” is not only the concrete embodiment of visual imagery, but also the direct

visual perspective of intrinsic links between things. People have such experience: if something is separated from its background (i.e., spatial structure), the intrinsic link between things changes, and the things will become completely different thing. For example, “legs” in the human body has walking function as an organic part of the body, but if the legs are separated from the body (legs amputated), they’re no longer walking legs, but a bunch of very soon rotten muscle. To grasp spatial structure feature is not only to know the visual attributes of things, but also to make fast comprehensive judgment about rules of internal connections. This is to grasp the nature of the specific meaning of things in existence (relative static state of motion). We must clearly recognize this point.

Temporal thinking generalizes and indirectly reflects the basic attributes of “time sequence”; that is to say, the nature of motion state (or significantly changing state). Obviously, the basic features of this thinking is to grasp the essence of things, from one-dimensional linear time axis. Language based logical thinking is most suitable for this occasion, because logical thinking can conveniently use means of analysis, synthesis, abstraction and generalization, to extract “the concept” from various attributes. As mentioned above, on this basis one can process more complex judgments by using these concepts; through judgments relatively simple rules can be determined; for more complex interrelated rules, one can make inferences through judgments. It can be seen that logical thinking can deal with generalization and indirect reflection of the essence of things, and also can deal with the internal links between things. The materials logical thinking uses (i.e., the objects of processing) are concepts expressed by words of language; methods (means) of processing include analysis, synthesis, abstraction, generalization, judgment, reasoning, etc. It was pointed out earlier that logical thinking, based on sequential and linear sequence of language symbols, has advantages of being responsive to events on one-dimensional time axis. However, a visual scene on a three-dimensional space can be transformed into a series of events along one-dimensional time axis, so long as no time limit that requires to make instant decisions. The principles of logical thinking can satisfy the needs of all human thinking. That is to say, logical thinking is suitable for the occasions of temporal thinking, and also for the occasions of spatial thinking. According to the essence of logical thinking, since it’s built on the basis of sequence of language symbols with one-dimensional and linear features, it is the most suitable reflection of a sequential, continuous variation process of movement. Then, obviously logical thinking is more suitable for temporal thinking. However, we disagree with the view held by the majority in the current academic community that names it “abstract thinking” or “abstract-logical thinking”, or even briefly “abstract thinking”. We believe that it should be scientifically called “temporal-logical thinking” or “linear-logical thinking”, which might be briefly referred to as “logical thinking”. The reasons for the naming are as follows.

First, abstraction and generality are the characteristics of all thinking, not only with logical thinking. If logical thinking prefixed with a descriptor abstract, or simply known as abstract thinking, it’s easy to make people mistakenly believe that only this thinking is abstract, which inappropriately raise logical thinking to a more

abstract level while belittle the other forms of thinking. And this is precisely a major ailing in the current academic community (especially in the philosophical and psychological academic community).

Second, logical thinking is based on sequence of language symbols, as indicated earlier, it's linear and sequential; therefore, it's the most suitable way to reflect the variation process of movement in which things unfolded in one-dimensional linear time axis. As a result of the analysis, the thinking is most reasonable, most logical to be named linear logical thinking or temporal logical thinking.

Finally, we can draw a conclusion from the analysis above regarding the definition of thinking. Human thinking is generalization and indirect reflection of the essential attributes and interrelations between things. This is achievable through spatial-structural thinking and logical thinking; these are two basic forms of thinking.

Spatial-structural thinking mainly reflects things' existence in space and the spatial-structural features, such as their forms and nature, their combination or arrangement, as well as the order and relation with other things in spatial positions. And mainly through this visual-spatial imagery to achieving the grasp of spatial-structural features; that is, achieving the grasp of essential attributes of things as well as the regularity of intrinsic links between things in a relatively static state (state of things).

Temporal-logical thinking (linear-logical thinking) mainly reflects essential attributes of motion of things (significantly changing of the state of things), and through the use of words to express concepts as well as to grasp essential attributes of things. Under the circumstance of no time constraints temporal-logical thinking can also respond to regularity of intrinsic links between things, mainly through components of concepts of judgment and inference to achieve this purpose.

It's true that two forms of thinking have their specific features from their respective distinct states (significantly changing state of motion and relative stationary state of existence), reflecting on things and the essence of the things, in their regularity of internal links. The two forms of thinking are indispensable, either of which cannot replace the other. They're equally important, and complementary to each other. Due to the fact that we know quite well about temporal-logical thinking, in the following section, we only take spatial-structural thinking for further analysis.

2.5 Processing Objects and Processing Methods of Spatial-Structural Thinking

2.5.1 Processing Objects of Spatial-Structural Thinking—Imagery

The object of thinking (thinking materials) has an important impact on the process and methods of thinking. Spatial-structural thinking material is mainly imagery. The translation of the term *imagery* (or *images*) in psychology in China, usually

uses the two renditions imagery or representation (表象/imagery 意象). Most psychologists believe that these two are just different in translation; their basic meanings are the same. However, there are a few scholars who believe that 表象 and 意象 have different meanings.²⁷ Yet, we do not distinguish between these two words and follow the popular translation, that is imagery (表象), in this book.

The so-called imagery (表象) is a reflection of things' images that have been perceived before (but not present to the sense organs at the present time), only a representation traces left in the past.²⁸ Things in the physical world act on human sense organs are sensations; perceptions are organization and interpretation of sensory information. They are produced on the basis of sensation, but different from sensation. This is because the formation of perception depends not only on the current sensory information, but also on human beings' knowledge and experience of the past. While sensations can only reflect individual attributes of things, perceptions can reflect various attributes of things; that is, the entirety of things. Having a common characteristic of intuitiveness, sensation, perception and unprocessed imagery are the visual reflection of things in the brain, parts of perceptual knowledge category as well as three different forms of perceptual knowledge from levels of low to high.

In addition to the common features above, imagery and perception are different from each other in the following ways.²⁹

2.5.1.1 Imagery Can Exist Separately from Specific Things

Imagery is the trace left by the perception in the past; that is, the concrete imagery of things that are kept in the minds of the people. Unprocessed imagery belongs to perceptual knowledge, but a big step forward than perception; unprocessed imagery can exist apart from specific things (and without sensory stimulation from specific things is no longer called sense perception), and may process imagery in the mind directly from specific things, and enable imagery to become more and more accurate and stable.

2.5.1.2 Imagery Has the Feature of Generality

Imagery is not only intuitive, but also has a certain degree of generality. It's due to the fact that imagery can reflect things intuitively with generality; therefore, by gradually processing an image (analysis, synthesis, abstraction and generalization, association and imagination etc.), it's possible to grasp the essence of things, so as to enable us to come to overall understanding of the nature of things from

²⁷Yang (1997).

²⁸Zhu and Lin (1991).

²⁹Zhu and Lin (1991).

superficial local understanding; or under the regulation and control of words in language, and enable us to develop an understanding based mainly from perceptual knowledge to conceptual knowledge of cognition by means of concepts.

Imagery can be divided into many types, such as visual imagery, auditory imagery, tactile imagery, and gustatory imagery, etc. In the process of spatial-structural thinking, it's often not one kind of imagery, but a variety of imagery that occurs, i.e., spatial-visual imagery. In other words, spatial-visual imagery is the main material for spatial-structural thinking. This is because:

First, the brain gets information from the world mainly through the visual sense. The American experimental psychologist Treicher showed human brain obtained 83% information from the visual sense, 11% from the sense of hearing, and less than 6% from all other sensory channels, including tactile, kinesthetic, olfactory, and gustatory channels.

Second, the overall and intuitive nature of visual imagery is conducive to spatial-structural thinking. Visual imagery presents overall, intuitive, spatial scenes for people to make an overall grasp of the spatial-structural characteristics of things, through intuitive perspective, spatial integration and comprehensive judgment, which is needed for spatial thinking. Other types of imagery (for example: auditory imagery and tactile imagery) can hardly do this.

Third, the structural and integrated nature of visual imagery is conducive to storage, recall and processing of thinking. Although sometimes visual imagery is fuzzy or not clear, yet always remain unbroken, and there's a certain structure. Even fragments of imagery reflect the local structure of things. This is easy to encode memory, which is conducive to the storage, recall and processing of thinking.

Due to the three reasons above, visual imagery is most conducive to the realization of the goal of spatial-structural thinking, so it's worthy to become the main material for this form of thinking.

As described in the beginning of Sect. 2.4, the spatial-visual imagery used in spatial thinking is of two types: one type reflects the attributes of things (referred to as "attribute imagery" or "object imagery"), the other reflects the structural relations between things (referred to as "relation imagery" or "spatial imagery"). According to the differences of the two types of imagery, spatial-structural thinking can be further divided into two categories: one class uses "attribute imagery" as the material of thinking (i.e., object of thinking processing), called for "imagery thinking"; the other uses "relation imagery" as the material of thinking, known as "intuitive thinking". In other words, the basic form of human thinking (or basic types) can be divided into three categories, namely, imagery thinking, intuitive thinking, and temporal-logical thinking.

2.5.2 Processing Methods of Spatial-Structural Thinking

The processing methods, according to whether the material of thinking (i.e., object of thinking processing) is attribute imagery or relation imagery, will be different.

This chapter will first introduce the processing methods which use attribute imagery as material of thinking (i.e., the processing methods of imagery thinking). As for the processing methods which use relation imagery as material of thinking, it will be discussed, together with intuitive thinking, in Sect. 2.1, Chap. 6.

The processing methods, which use attribute imagery as material of thinking, usually include analysis, synthesis, abstraction, generalization, comparison, classification and imagination, each of which uses imagery as the object of mental operation.

Analysis is a mental operation that breaks down complete imagery into a number of components (each component is also an independent imagery). For example, rabbit imagery can be decomposed into the imagery of rabbit's eyes, ears, mouth, fur, claws, tail or other parts, which is imagery analysis.

Synthesis is the process of mental operation that combines the same kind of imagery to make it complete and more accurate. For example, the imagery of a rabbit's produced from the combination of a rabbit in static or dynamic states and in a variety of different situations.

Abstract refers to the mental operation that draws out attributes of the same things with the same nature, and discards the non-essential attributes. This is a huge misunderstanding since it was traditionally believed that logical thinking can achieve abstraction only through language presentation. A typical manifestation of this mistake is to call logical thinking as abstract (logical) thinking (the implication is that only logical thinking can abstract). Arnheim strongly criticized this by pointing out that³⁰ the use of imagery can achieve various levels of abstraction, and also may sometimes reach the level of abstraction where other general concepts cannot reach. Arnheim cited several examples³¹:

- When the baby, tells apart an object (such as identifying a bottle), from numerous objects in the complex external world, it's an initial abstraction. The baby has caught the essence of the things using visual imagery, otherwise it would be impossible.
- When being able to extract a simplified form that represents an object in the physical world from the external stimulus, the abstraction (using imagery to abstract) of the representation reaches a relatively high level; for example, recognizing a reverent attendant with a bowing imagery, aside from other specific characteristics, such as the figure, face, and clothing.
- A clock exhibits at the Nagasaki Museum in Japan is a case with a particular and abstract meaning difficult to express with concepts of language. An ordinary clock with a high degree of abstract meaning cannot be a manifestation of its master or the character of its master. The damaged clock at Nagasaki Museum stops at two past eleven; its abstract meaning is shocking. Since time freezes at this moment, people immediately recall the atomic bomb explosion of the terrible moment and the tragic scene, so as to inspire people to maintain a strong

³⁰Arnheim (1969).

³¹Arnheim (1969).

sense of peace and to oppose war. This is the essence of the problem as well as the significance of atomic bombing which is what and also the museum wanted to show to the masses, and the clock will become the representative of the “abstract thing”. Obviously, on this particular occasion, the abstract meaning and social effect generated by the clock is unable to be surpassed by long winded speech concept.

Summary is a kind of mental operation that generalize from things with the same essential attributes. Currently influential psychology textbooks in China³² stated that summary “has two forms: one is comparison between different things, according to the external characteristics of things, abandoning features different from each other and generalizing from their common features. This is the primary stage of generalization, perception and imagery. The second form of summary is generalization of an object and a phenomenon, or a series of objects and phenomena to be summarized, according to the essence of things. This is generalization of the thinking level, an advanced form of generalization”.

According to this view, spatial-structural thinking with imagery as object of mental processing can only achieve the primary form of summary, only logical thinking can realize the advanced form of summary. This really is a misunderstanding. We would like to ask that in the ever-changing battlefield, where every complex situation that the enemy and us are facing, by what means does a brilliant commander can make a decisive decision in the moment. Never a step-by-step logical reasoning is followed. Only a dull commander mainly relies on logical thinking to command the war. With overall war situations, a commander must use spatial-structural thinking, which can help to judge the situation from the big picture, grasp the situation of both sides, and have a global picture in mind. In so doing, a commander will not be confused by local, specific facts or the surface features of a phenomenon. Here “having a global picture in mind” refers to the grasp of features of spatial structure of the war situation as a whole; namely, the state of both sides in a war, related factors, mutual antagonism, interaction (such as the troops deployment, collaboration with neighboring troops, ammunition supply, rear support, combat morale of both sides and other elements of mutual confrontation situation). Is it not a reflection of the nature of things with spatial-structural features, such as spatial imagery (attribute imagery and relation imagery)? How do you think that generalizations based on imagery are either inferior or second-rate?

Arnheim³³ refuted the argument cited above using imagery as a high level summary, which is very convincing. This case in point describes an imagery of mathematical theory of cone cutting as the key role of the theory. Arnheim pointed out that³⁴ in the process of establishing the “cone cutting theory”, Kepler and others found some common properties in the images of circle, ellipse and hyperbolic. These three kinds of basic geometric patterns have existed since ancient times, but

³²Ye and Zhu (1992).

³³Arnheim (1969).

³⁴Arnheim (1969).

they're not related to each other. Through cone cutting with formation of new imagery, Kepler et al. found that common characteristics exist between circle, ellipse and hyperbola—as a result of cone cutting, with the difference only lies in different ways of cutting. So three originally uncorrelated geometric elements are now closely linked together by cone cutting theory, forming a certain spatial-structural geometric system. Generalization of this higher level theory does not rely on words and concepts as basic logic, but totally dependent on imagery to generalize—the three basic geometric figures as the original imagery through cone cutting forming a new image and discovering common attributes of the geometric figures, extending to all the three kinds of figures. How can it be said that this imagery of important theoretical findings is inferior or second-rate?

Of course, it cannot be denied that any theory of innovation is not separable from logical thinking, and it's equally important that any theoretical innovation cannot be separated from spatial-structural thinking. On this issue we will make an exhaustive demonstration in Sect. 2.1, Chap. 6 “six elements structure of creative thinking model”.

As mentioned above, in the process of abstraction and generalization, essential attributes of things are involved. Spatial-structural thinking reflects only essential attributes in things in their existential states (namely the essential features of relative static state), though essential attributes can be individually reflected through temporal-logical thinking, it's more effective to grasp the attributes through spatial structure, or by blending spatial-structural thinking and temporal-logical thinking. We must learn this by heart.

Imagination is the mental processing of original multiple images through adjustment, integration and reconstruction. Through imagination, all participating images in integration are more or less changed from the original components (and in the process of synthesis and analysis, the components of the original imagery does not change) and form a new image, “imagination imagery”. Goddess on the moon and other typical characters of novels are examples of the integration of new imagery; that is, imagery of imagination. Due to imagination, the original imagery is transformed from a variety of images, and there's a certain novelty and even creativity in the new imagery. According to different degrees of novelty, it can be further divided into two kinds: *reconstruction imagination* and *creative imagination*. Reconstruction imagination is a new imagery of what others described and you did not experience before (such as dinosaur in the ancient times); creative imagination is from no ready-made basis, not described by anyone and is independently created imagery. Obviously, reconstruction imagination and creative imagination are of special significance to planning of writing, artistic creation, theoretical construction and other creative activities.

To accomplish imagination, the following conditions are necessary.

1. *There should be a wealth of images reserves.*

Imagery is the basic material for imagination. The fuller the imagery, the richer contents imagination will have. As imagery is obtained through perception, it calls for more observation and accumulation.

2. *One should be good at association.*

According to Aristotle's law of association, we can form association from three aspects: **similar association**, such as similar shapes; **reverse association** (contrast association) to think from things contrary in nature or from the appearance with stark contrast; **associative association**, such as things that are not similar, though not opposite, in nature, function or shape but logically connected in some way.

It has been seen that association is easier if things are similar in nature, in function, in shape or in logic. According to association of the three aspects, more images will bring more benefit to imagery integration and reconstruction (because integration and reconstruction are always in accordance with the things between certain connection and structure), and imagination.

3. *Regulation and control of the second signal system are needed.*

According to Pavlov's theory, imagination (especially creative imagination) is the result of cooperative activities of two kinds of signal systems. Usually the first signal system refers to the external stimulus received directly from sensory organs. Language is the second signal system. This kind of mental processing activity uses imagery as the material for processing, so it should be the main function of the first signal system. But in order to expand and deepen contents of imagination, concepts and language of the second signal system should be used, and the regulation and control of language cannot be divided. Even association is inseparable from language concepts. For example, to achieve similar and reverse association, we often have to know which attributes are similar, or opposite; to get hold of association, we need to know whether or not there's a logical connection between things. These are inseparable from the guidance and control of language concepts. As for the formation of creative imagination, due to the novelty of its contents, innovation has a higher requirement. The two signal systems are necessary to cooperate. On this issue, we will also make further discussion in Sect. 2.5, Chap. 3 "the thinking process and features of artistic creative thinking".

We have introduced spatial thinking in five main psychological operations (analysis, synthesis, abstraction, generalization, imagination). In addition, there are other operational methods, such as comparison and classification. Since they're relatively simple, we will not specify them here.

2.6 Comparison of Spatial-Structural Thinking and Animal Thinking

Since spatial-structural thinking materials (object of thinking) are mainly images; and images are intuitive, people tend to confuse it with animal thinking. We believe that the confusion must be clarified.

As mentioned before, human thinking is a special function obtained through evolution of millions of years in the process of great effort with nature, in order to

seek survival and development. The basic purpose of thinking is to solve all problems faced by human beings. In other words, thinking is always linked with problem-solving, and even many psychologists believe that thinking is problem-solving. The premise of problem-solving is to be able to make correct judgment of things, to discriminate things, to determine the nature of things, to make decisions under the situation encountered, and so on. Different situations require judgment of different forms. Therefore, the ability to make a correct judgment has become problem-solving ability; that is the main symbol of thinking ability. From this view, many psychologists believe that animals are similar to humans in terms of thinking, and they cited numerous examples. For example, animals generally have the ability to avoid disadvantages, quickly find their food, and judge whether they're in time to escape from danger (such as a mouse sees a cat). The closer the genetic relationship between humans and animals is, the more powerful the ability is. Calvin William³⁵ pointed out that, average dogs cannot untie the belt tied to a pole, but a chimpanzee may be able to do so. In a cage locked by a dog belt, monkeys can be locked safe inside since they cannot reach the buckle and unlock it. However, a chimpanzee may be able to open it. So for chimpanzees, a real lock will have to replace the dog buckle, and you should never leave the key in the cage.

All examples above prove that many animals (especially primates) have certain abilities to solve problems; that is, having ability to think. However, we believe that this kind of animal thinking is too different from human spatial-structural thinking on a fundamental level. Animal thinking is based entirely on the basis of direct perception and the use of the specific imagery for thinking (materials of thinking). Once things present disappear, the perception of imagery no longer exists, thinking disrupts. While spatial-structural thinking of humans not only relies on specific imagery of current perception of things as thinking materials, but can also use imagination (mainly imagination). As mentioned above, imagination comes out of perception, but it can exist independently from current specific things and undergo further processing (such as analysis, synthesis, abstraction, generalization and imagination). It's impossible to do this type of processing, using only specific shape of the current perception as thinking materials. We can prove this, using chimpanzees as an example, which are primate, closest to humans with the most advanced thinking skills.

Famous psychologist Kohler once conducted a large number of experiments³⁶ for 4 years about animal thinking on the Tenerife islands with chimpanzees. During the experiment, he put a banana or other food on top of an iron cage, and then gave the chimpanzee a certain condition, and made it use the condition to get the food. Such conditions could be a long bamboo pole, or a few segments that could be connected to the short bamboo pole but also piled up in order to climb up the box. After a period of exploration, trial and error, and thinking, the chimpanzees

³⁵Calvin (1996).

³⁶Bigge (1982).

eventually learned to use a long bamboo pole, or a few short bamboo rods connected, or a few boxes on top of each other for climbing to obtain the food hanging on top of the cage.

The experiment proved that chimpanzees have the ability to think by using simple tools to solve a problem (some people think this does not belong to logical thinking, and they simply deny or not recognize this as ability to think. We believe that this is not a materialistic attitude). However, Kohler was confused that he failed to make the chimps learn to break down a twig on the tree and use it to reach the food.³⁷ Kohler did not find the answer. Half a century later, many psychologists are still unable to make a convincing explanation of this phenomenon. In fact, the reason is not complicated—Chimpanzees use direct perception of specific things as their thinking material, rather than imagery. In chimpanzees' perception, the branches and the trunk are connected as a whole. Without using imagination in thinking, a chimp will never decompose the image of "tree" in its brain (the image of the branches decomposing from a tree); while, humans do not rely on the current specific perceptual objects as the object for thinking. Therefore, humans can easily do it (it can be done only by a simple mental operation of "imagery analysis"). This is the fundamental difference between human's spatial-structural and animal thinking. For a long time, psychologists at home and abroad have debated fiercely for many times about whether animals have thinking, and what differentiates animal thinking from human thinking. Various volumes appeared and some of them were plausible (e.g., some argue that squirrels store nuts in winter, so that animals have advanced planning, which is superior to human thinking³⁸). Tracing the reasons for the arguments, it's found that most arguments focus on the fact, the phenomenon, and the behavior, yet fail to tightly grasp the essence of thinking materials. Therefore, it's hardly possible to understand the similarities and differences between animal thinking and human thinking.

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³⁷Arnheim (1969).

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