Research on the Cognitive Mechanism of Plant Taxonomy from the Perspective of Categorization

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Abstract: From the perspective of category theory of cognitive science, plant classification is a cognitive process and the result of conceptualization and categorization of human cognition. The plant classification system is the category system. The categories of “family” and “genus” in the vertical dimension are closer to the basic level category, and the members of the category in the horizontal dimension show typical prototype effect. It is helpful for the study of plant taxonomy to fully understand the category and categorization of plants.

1. Introduction

The origin of plant taxonomy can be traced back to the primitive society where human beings came into contact with plants. It is the oldest comprehensive branch of plant science. One of the main tasks of plant taxonomy is to classify and identify the numerous and complicated plant kingdoms and arrange them in a systematic way so that people can know and utilize plants.

2. Category and Categorization

Category refers to type and scope. Categorization is the ability of people to perceive similarities between different things and classify them (Evans & Green, 2006). As early as more than 2,000 years ago, Aristotle made a systematic exposition of category in “Category”. He regarded category as a basic concept derived from the analysis of different aspects of object and discussed ten famous categories. Category theory has experienced the development from Aristotle's classical category theory to Wittgenstein's modern category theory (prototype category theory). Ungerer & Schmid (1996) summarized their research results and pointed out that prototype category is a kind of fuzzy set. The first is the hierarchy of internal members. The internal members of prototype category are connected by family similarity. There are central members and marginal members. Members with more typical characteristics constitute the central members of category. The second is the fuzziness of the external boundary. There is no clear boundary between categories, and the edges of the adjacent categories often overlap.

3. Category Theory and Plant Classification

3.1 Basic Principles

Prototype category theory regards categorization as a cognitive ability of the human brain and holds that the classification of objective things is the result of the interaction between its own attributes and subjective and objective factors such as human body experience. Category theory provides a new perspective to explain the cognitive mechanism of plant classification: plant classification is a cognitive process, the result of human cognitive conceptualization and categorization. Plant classification is essentially a process of categorization. Plant classification system is category system, and its different classification levels are different categories.

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3.2 Dimension of Category

Rosch (1978) thinks that category system can be divided into vertical dimension and horizontal dimension. The former is related to the capacity of specific categories. The higher the category level, the more items it contains. The latter reflects the difference between categories in the same vertical dimension. Taxonomic elements of plants can also be divided into vertical and horizontal dimensions, with characteristics of corresponding dimension categories. The phylum, class, order, family, genus and species are in the vertical dimension, and the species are at the lower end of the vertical dimension. Each category member is a corresponding horizontal dimension category.

3.2.1 The Vertical Dimension of Category

Rosch & Mervis (1975, 1976) divides the vertical dimension category into three main levels: the upper category, the lower category, and the basic level category (Rosch, 1976). The upper category emphasizes the generality of the category, and the lower category emphasizes the specific function of the category. The basic level category has the unity of perception, the unity of image schema, the perceptibility of perception, the consistency of behavioural response, the convenience of language and the basic characteristics of information organization. (Rosch, 1975, 1978; Lakoff, 1987)

3.2.2 The Horizontal Dimension of Category

The horizontal dimension of category is related to the principle of perception of natural structure and has a prototype effect. That is. Some category members are more typical than other members in the same category, which is called category prototype. Category members are related to each other by family similarity (Rosch, 1975). Category prototype has the most category-related attributes.

3.3 Basic Level Category in Plant Classification System

The characteristics of basic level category between abstract and concrete meet the most basic cognitive needs of human beings. Therefore, in the process of plant cognition and utilization, it is very important to recognize the basic level of plant scientific classification.

3.3.1 Cognitive Subject Perspective

According to the characteristics of basic level category which can properly refer to things or phenomena in daily life, this paper designs a questionnaire to explore the basic level category of plant classification from the cognitive characteristics of people.

(1) Research content

The questionnaire is divided into four versions and randomly distributed to all subjects. Three types of questions were designed for each questionnaire: the subjects were required to identify and distinguish different genera of plants; Require research objects to identify and distinguish different plants; The subjects were asked to list 3 species of each of the 5 types of plants “grass, wood, grain, fruit and vegetables”. Item 1 and item 2 select plants from *Liliaceae*, *Leguminosae*, *Compositae*, *Pinaceae*, *Rosaceae* and other plants that people contact relatively more in daily life as identification objects, and only the same family plants appear in each questionnaire. According to the differences of cognition of species and genera and the priority of cognition of plants, we can judge which classification category of plant science is closer to the basic level category.

(2) Research object

There were 240 non-botany and related research subjects in different age stages. There were 132 males and 108 females. Among which, 30 under 21, 60 between 21 and 35, 60 between 36 and 50, 60 between 51 and 65, and 30 over 65.

(3) Data analysis

A total of 240 questionnaires were distributed in this survey, 240 of which were recovered, with a recovery rate of 100%, of which 237 were valid. Based on the data analysis of Item 1 and Item 2, the recognition rates of plants in genus and species categories are 16.7% and 10.1% respectively. Compared with species category, genus category is closer to basic level category. In Item 3, subjects listed 598 species of plants (excluding duplicates), 341 of which could be classified into the

category of plant science, accounting for 57.0% of the listed plants. The specific distribution is shown in Table 1.

Table 1 the Distribution of Plants Listed by Subjects in the Category of Scientific Classification

Category	Family	Genus	Species	Variety	Total
Frequency	74	198	64	5	341
Proportion (%)	21.7	58.1	18.7	1.5	100

From the subject's identification of plant scientific classification category and the scientific classification distribution that can identify plants, it can be seen that genus category has obvious priority in people's cognition of plants and should belong to basic level category in plant scientific classification category.

3.3.2 Lexical Perspective

Cognitive linguistics holds that “recognizing and naming a new thing is a cognitive process to determine its category” (Zhao Yanfang, 2001). Words are symbolic forms that use language to fix categories. The characteristics of classified words can also reflect their category characteristics.

(1) Data source

The plant species information in this paper is based on the “List of Chinese Plant Species” (Wang Yuhua et al., 2012), combined with “Flora of China” (Qian Chongzhu et al., 2014) and “A Guide to Chinese Higher Plants” (Institute of Botany, Chinese Academy of Sciences, 1994), to supplement and correct the missing and wrong items, and to add 212 species of bryophytes. The revised “List of Plant Species in China” (hereinafter referred to as “List”) contains 31,333 species and 8,937 subtypes (including subspecies, varieties, variants, varieties, etc.).

(2) Word length analysis

Different level categories have the same correspondence with words in the language. Therefore, words are divided into basic level words, and upper and lower meaning words corresponding to basic level words. Word length is the length of a lexical unit, which is expressed in letter words as the number of letters each word contains. Chinese word length refers to the number of Chinese characters contained in a Chinese word, and can also be expressed by syllable number. Generally speaking, basic category words are the shortest, and the further away from the basic category, the longer the length of the words expressed.

Table 2 Statistical Table of Plant Classification Word Length

Word length	Statistic	Family	Genus	Species
Single syllable	Frequency	19	64	49
	Proportion	4.8%	1.9%	0.2%
Double syllable	Frequency	162	902	1531
	Proportion	40.6%	26.3%	4.9%
Three syllables	Frequency	212	2206	5422
	Proportion	53.1%	64.6%	17.3%
Four syllables	Frequency	6	221	10226
	Proportion	1.5%	6.5%	32.6%
More than five syllables	Frequency	0	25	14105
	Proportion	0.0%	0.7%	45.0%
Total	Frequency	399	3418	31333
Average word length	Numerical	2.51	2.78	4.24

By analyzing the description of the attributes of various categories of plants in “A Guide to Higher Plants in China”, we believe that phylum, class and order belong to highly generalized abstract categories and belong to upper categories. Variants, subspecies and deformation categories

show very specific attributes, subordinate category. However, it is not clear which category of family, genus and species belongs to the basic category. For this reason, we have made an analysis of the term growth of the members of families, genera and species in the List (see Table 2 for details). Among them, the longest category word is eight syllables, and families and genera are mainly trisyllabic words, accounting for 53.1% and 64.6% of the total respectively. There are mainly five syllables or more, accounting for 45.0% of the total. Words of families and genera with less than three syllables (including three syllables) account for 98.5% and 93.1% respectively. There are 77.6% of words with more than four syllables (including four syllables). The average word length of species is 4.24, which is much higher than 2.51 and 2.78 of families and genera. However, the word lengths of families and genera are not much different. Compared with species category, families and genera are closer to the basic level category of plant classification category, with trisyllabic words as the main words, with simpler names and clearer references.

3.4 Prototype Effect in Plant Classification System

In the horizontal dimension of category, prototype effect in plant classification system is embodied in many aspects. For example, there are 79 species members of Euphorbia in the list of plants in China (Wang Yuhua et al., 2012). Among them, there are one species named after *Euphorbia pekinensis* and 53 species with *Euphorbia pekinensis* as its morpheme, showing typical prototype effect. The marked “pattern genus” and “type species” are also category prototypes of corresponding families and genus categories respectively.

Prototype effect is an important factor affecting the lexicalization of plant concepts. On the one hand, the perceived similarity with the central example is the basis for lexicalization; On the other hand, the similarity with the example of the neighboring center is also the basis of lexicalization. Modern plant classification system emphasizes the clarity of category boundary and has dichotomy. Once a certain plant category is established and named in modern plant classification system, it is exclusive. That is, in the classification system of plant science, any plant cannot exist in two categories at the same time. No matter what kind of features a plant is based on when it is named initially, once the category is established, its members are compared and classified according to the rules of modern plant classification system.

4. Enlightenment to Plant Taxonomy

4.1 Propositional Judgment and Category Boundary

Botanists try to establish necessary and sufficient conditions for all order elements, and classify category members who cannot meet all necessary and sufficient conditions as either new categories or new categories. However, category theory holds that the boundary of a category is fuzzy. The more category members with common attributes of the category members are closer to the category center, the further away the category members with fewer common attributes are from the category center. The evolution of species is continuous, so the adjacent categories in the evolutionary relationship should be continuum, and the boundary of the classification order element is fuzzy in nature, so the intersection of classification categories and the existence of fuzzy boundary should be accepted and allowed.

4.2 Prototype

The classification category of plant system shows obvious prototype effect. As a cognitive reference, category prototype plays a vital role in plant classification cognition, but it is not fully reflected in the Chinese classification naming system. Among the current authoritative plant classification and cataloguing resources in China, only “Flora of China” has indicated “type genus” and “type species” in some families and genus categories and members, which lacks systematicness. At the same time, according to the prototype category theory, category members are related through family similarity, and some categories should allow the emergence of multiple prototypes. It is suggested that in the future revision work, it should be gradually supplemented and improved.

4.3 Classification and Naming

Compared with the classification cognition of animals, the evolution and kinship of plants through morphology are not significant, so they rely more on modern molecules and chemical analysis to provide information. If we introduce a note on the prototype degree of category members (refer to Rosch's goodness of example ratings, 1975) when naming species, reflecting the prototype and evolution direction of category members, we can greatly reduce the cognitive cost, and do not have to spend a lot of time on which category most edge members belong to.

4.4 Nomenclature Conventions

“International code of botanical nomenclature” regulates the naming of plants that are commonly used in the world, but so far there has been no clear naming standard for Chinese plants. From the perspective of cognition, the embodiment of basic level category and category prototype in naming is not only the natural embodiment of people's cognitive mechanism, but also the most efficient cognitive way. Therefore, the naming of plants with “distinguishing morpheme+generic morpheme” is the most cognitive efficient naming method. In terms of the growth mode of Chinese plant names, the cognitive goals can also be effectively achieved through the overlap of generic morphemes and the participation of local morphemes. According to the development of plant taxonomy and the cognitive characteristics of plant classification, identification and nomenclature, it can be used as a reference for the formation of Chinese plant nomenclature.

5. Conclusion

Plant taxonomy has a history of thousands of years. Plant taxonomy cognition is a very complicated process, condensing the sweat of generations of researchers. This paper analyzes its cognitive mechanism from the perspective of prototype category and idealized cognitive model, and holds that plant classification is categorical and classification rank is category. The boundary of classification category of plant science is fuzzy, its vertical dimension “Genus” category is basic level category, the members of horizontal dimension category have prototype effect, and people's psychological process of plant identification and cognition are also different. The categorization of plant taxonomy can provide useful guidance for its research and teaching.

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