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Research on the Properties and Meaning of Quantifiers in Natural Language

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Abstract: Whether in daily communication or philosophical discussion, there are many expressions involving quantifiers. Quantifiers are popularly used in oral language. This paper discusses some basic problems of Quantifiers in philosophy and natural language. one side, Quantifiers are important in philosophical research as they are involves in the basic issues of epistemology, especially in those of relations, truth, universals and existence. But quantifiers in Chinese are very often omitted in expression. On the other hand, we discusses quantifiers from linguistic perspectives, and explains some characteristics of quantifiers and some significance of quantifier theory. Quantifier theory can provide theoretical support and explanation methods for language research. This paper shows how the knowledge of quantifier and quantification can help to realize the ways of their working in our language and to have a better understanding of their contributions to the above philosophical issues. The understanding of quantifier syntax and semantics is helpful for us to enrich logic theory and provide resources for the development of logic theory.

Keywords: Universal Quantifier, Existential Quantifier, Truth Conditions, Natural Language

1. Introduction

Quantifier is a basic way of language expression. First-order logic, also called quantifier logic, reveals some characteristics of quantifiers, which provides beneficial help for us to know quantifiers. The theory established by linguists to study natural language is usually to explain some phenomena in natural language, such as how to describe the syntactic structure of a natural language, how to realize the semantics of sentences and how to use sentences in natural language. These are the three basic fields of modern linguistics: syntax, semantics and pragmatics. In 1950s, Chomsky's syntactic theory, which is based on modern logical syntax, caused a sensation in the whole linguistic field. The development of formal semantics has greatly promoted the study of semantic models of natural languages, such as Montague grammar, which is based on the (logical) semantics of formal languages founded by Tarski. The development of pragmatics tries to establish the relationship between linguistics and other disciplines, such as the relationship between language and cognitive science, psychology, language and society, etc. These developments were originally proposed by Wittgenstein and Austin, who were dissatisfied with the way that classical logic only deals with the true and false sentences, and proposed that language use should be discussed. It can be seen from this that the development of the three branches of modern linguistics is inseparable from the development of modern logic. This paper focuses on quantifiers in natural language, thus revealing some relations between logic and language theory: the development of language theory can enrich logic theory and provide resources for the development of logic theory; On the contrary, logic theory can provide theoretical support and explanation methods for language research.

2. Quantifier Theory of Traditional Logic

As early as Aristotle's time, people had an understanding of "quantifiers". Aristotle is the founder of logic, and his syllogism theory is the earliest systematic logic theory [1]. In syllogism, the most basic sentence form is "s is p". On this basis, Aristotle proposed adding quantifiers and negation, thus obtaining four basic propositional form: all (some) s (not) is p. There are two quantifiers introduced here: "all" and "some".

People often use quantifier expressions such as "all", "every" and "any". Such expressions can express general, universal and regular things. Obviously, this expression has the strongest certainty. This kind of expression can be called universal quantifier, which means "all", and it can exclude exceptions.

People often use quantifier expressions such as "some", "a few of", "a little" and "certain". Such expressions do not mean general, universal and regular things, but express individual things and partial things, but they also have certainty and are clear certainty. This kind of expression can be called existential quantifier, which is represented by "there is one".

In natural language, both the universal quantifier and existential quantifier are adjectives, which modify the nouns behind them. For example, in "all economists are smart people", "all" modifies the following "economists". According to the analysis of traditional logic, the "economist" is distribution in this sentence, but the "wise man" is not distribution. Because "all" is only related to "economists", but has nothing to do with "smart people", or rather, it only determines "smart people", but not "smart people". In "some courses are required courses", "some" modifies the following "courses". According to the analysis of traditional logic, the "course" in this sentence is not distribution, but the "required course" is distribution. Because "you" is only related to "class", but has nothing to do with "required course", or, it only determines "class", but not "required course".

The sentence "all S are P" means that all individuals in S belong to the range of P; The sentence "some S is P" means that at least one individual in S is in the range of P. These two quantifiers are called universal classifiers and existential classifiers respectively. Of course, the ability of traditional logic to deal with natural language is limited. For example, it can't deal with the problem of multiple quantifiers in the sentence "Everyone loves someone". The syntax and semantics of traditional logic are almost the same as those of natural language, and this explanation is relatively intuitive. The description of quantifiers in traditional logic based on Aristotle's logic is bound by natural language, and the understanding of quantifiers is limited. However, from the point of view of modern logic, or from Frege's point of view, the syntax and semantics of universal quantifiers and existential quantifiers are different.

3. The Quantifier Theory of Modern Logic

It was not until Frege put forward modern logic that people clearly knew that the essence of the sentence structure "All S is P" is "For any individual x, if x is S, then x is P". Therefore, complex sentence structures can be accurately constructed from the simplest single sentence structure Px (individual x is P). An important difference between Frege's theory and Aristotle's theory is that Aristotle's sentence form is a subject-predicate structure, which is close to the basic form of sentences in natural language [2]. However, Frege's theory abandoned this subject-predicate form and replaced it with another form, forming a special artificial language, which can grasp the meaning of sentences in natural language, such as the understanding of "all S is P" mentioned earlier [3]. Therefore, this kind of artificial language can be regarded as a model of natural language. Since Frege put forward modern logic theory, people's understanding of language, economics and logic has made great progress. Although Frege's theory can't deal with many phenomena in natural language, such as "quantifiers", it is important that Frege's theory provides a way to study the "deep structure" of language [4]. On the basis of Frege's logic theory, Tarski put forward formal semantics in 1936, which further enriched and developed the research methods of modern logic and was widely used in various subjects. Semantics has also developed into an important branch in linguistics.

The scope of the universal quantifier is very clear, which refers to every object in the individual domain, that is, any object. Therefore, its syntactic form is as follows: "any thing x, x..."... is the expression of predicate, and it is completed, such as the above sentence: any x, if x is an economist, then x is a wise man. Therefore, quantifiers not only have syntactic features, but also have semantic features. On the one hand, it has syntactic features. The x it defines is not only related to "economist" but also to "smart person", so it modifies the whole sentence, not just the subject. On the other hand, it is the semantic features formed by this syntactic feature. The quantifier also has a vacancy, so it seems to be a function and needs to be supplemented [5]. As mentioned earlier, quantifiers express individual domain. As far as the universal quantifier is concerned, its scope is all individuals, so it is necessary for all individuals in the individual domain to match the concept. Therefore, the universal quantifier is not an expression of individual things, but an expression of universality.

In addition to the universal quantifier, there is also a kind of expression called existential quantifier, which is often expressed by words such as "there is a..." or "there is one... exist". It not only has definite certainty, but also indicates a definite scope. On the one hand, existential quantifiers have definite certainty. Its syntax can be expressed as: "There is something x, x is...", and... is the expression of predicate. For example, "there is an x, x is an economist and x is a wise man". On the other hand, the existential quantifier indicates a definite range, that is, it refers to an object in this individual domain. Therefore, if a sentence with an existential quantifier is true, the concept represented by the predicate modified by the quantifier should be at least suitable for a certain object in the individual domain. Combined with the previous examples, if the sentence "some economists are smart people" is true, it must be: there is an individual who is an economist and a smart person. Here, "having an individual" means that there is at least one thing.

From the meaning, truth and falseness of quantifiers, if a sentence with a universal quantifier is true, then the concept represented by the predicate modified by the quantifier should be suitable for every object in the individual domain.

For example, if the sentence "All economists are smart people" is true, then it must be, if something is an economist, then it is smart people, and everything is the same. In other words, for anything, if it is an economist, then it is a wise man. Whether it is "everything" in the former expression or "anything" in the latter expression, it means exhausting the individual domain. The expression "if..., then..." is used here. This is a hypothetical way, not a conclusive way. In natural language, universal expression is a definite way, while in syntax, universal quantifier is a hypothetical way. Does this syntax conform to the expression of natural language? On the surface, it is a problem of syntax and semantics, or logic and language, but in fact it contains epistemological problems.

4. Quantifiers and Epistemology

The number of individuals in the individual domain is infinite. The universal expression "all" concludes the whole, so the universal quantifier indicates the whole of the individual domain, that is, every object. We can also give each object in the individual domain a name. In this way, if the sentence "All economists are smart people" is true, then the situation must be that if x_1 is an economist, then x_1 is smart people; And if x_2 is an economist, then x_2 is a wise man; And if x_3 is an economist, then x_3 is a wise man; And..... The ellipsis here shows that we can continue to name and express it all the time, but we can't end it anyway, because the object is infinite. In fact, this shows that we can recognize the situation of some individuals in the individual domain, so we can judge the situation of some individuals, but we cannot recognize the situation of each individual in the individual domain, so we cannot judge the situation of each individual. Therefore, what the universal quantifier expresses is actually beyond our understanding. It reflects a contradiction between people's understanding and expression. That is, cognition has limitations, but expression exceeds this limitation [6]. That is to say, we can say sentences with universal expressions and make corresponding judgments, but such sentences and expressions are actually beyond our cognitive ability. We realize that the problem here is discovered through the understanding of the universal quantifier, that is, through the understanding of the syntax and semantics of the universal quantifier. Therefore, "every thing" and "any thing" express the judgment of the whole individual domain, while the syntax of "if..., then..." weakens this judgment, and by naming it in this syntax, it expresses the universality and general characteristics that the full name expression hopes to express.

The next question is also related to epistemology. As mentioned earlier, since what the universal expression expresses is beyond people's cognitive ability and scope, how can such expression be true? Or, how can people realize that such expression is true? That's true. The judgment made by the universal expression is beyond people's cognitive ability, so we can't judge whether this expression is true or not. But this doesn't mean that we can't say the true conditions of such expressions. In fact, the syntax of the universal quantifier just tells us under what circumstances the things expressed in such sentences are true. For example, the above example shows that the sentence "all economists are smart people" is true only if all individual things, that is, every object in the individual domain, satisfy the requirement that "if … is an economist, then … is a smart person". That is to say, as long as one individual does not satisfy this situation, this sentence is not true. Therefore, we don't know whether this sentence is true or not, but we know under what circumstances it is true. Further, we don't know whether this kind of sentences are true, but we know their true conditions, that is, under what circumstances they are true.

From the syntax of quantifiers, the syntax of existential quantifiers is obviously different from that of universal quantifiers. Universal quantifiers are expressed in a hypothetical way, while existential quantifiers are expressed in a conclusive way. In the syntax of existential quantifiers, the expression "and" is used. And the proposition containing "and" is to connect two judgment sentences in a positive way, so it is also a judgment way. From the semantic point of view of quantifiers, as Frege said, what quantifiers mean is a function, which takes concepts as its own arguments. Existential quantifiers and universal quantifiers are both quantifiers, and they are the same. Concept is a function from object to true value, and individual domain provides a range for selecting objects for concept, so it is the limitation of concept. Individual domain and concept are not on the same language level, but higher than concept. Therefore, what quantifiers mean is higher than what predicate means. We need to recognize the syntax and semantics of quantifiers and find out their properties before we can further discuss the problems related to them.

There is the word "existence" in natural language, which is different from quantifier expression. Quantifier expressions are usually used to modify common nouns, but not names [7]. This is true whether the universal expression "all" or the expression "some" exists. But the word "existence" is not like this. It is not to modify nouns, but to judge nouns. It is different to regard existence as a quantifier or a predicate. Of course, there are also problems in understanding language. In fact, even from the perspective of language understanding, such understanding is problematic. Frege once discussed that in daily expression, according to language habits, the word "existence" is usually followed by a common noun, that is to say, the word "existence" cannot modify a name [8]. According to this view, "perpetual motion machine" in "the existence of perpetual motion machine" can only be a common noun, but not a name. Even if this view is reasonable, we can think that it is aimed at German and not necessarily suitable for other languages. For example, in Chinese, can't the word "existence" modify a name? For example, "the existence of Shanghai", or "there is Shanghai". We generally think that "there is a..." also means existence, so it has almost the same meaning as existence. In my opinion, Chinese grammar is not as strict as western languages, so sentences like "the existence of Shanghai" and "there is Shanghai" seem to be correct. But in terms of language habits, there are still some differences.

5. Quantifiers and Natural Language

Next, we consider the problem of quantifiers in language. Universal quantifiers and existential quantifiers are very special quantifiers. After Frege, Tarski and later logicians have studied them, their properties have become very clear, that is, the study on the syntax and semantics of classical quantifier logic. However, in natural language, there are many forms of generalized quantifiers that have not been fully studied, and the nature of these quantifiers is a common interest of logicians and linguists. Let's take a few examples first:

(1) There are only a limited number of people in the world.

(2) Many Chinese people like to eat chili.

(3) Most students are diligent.

(4) At least half of the Americans agree with the result.

(5) At least five students are interested in logic.

The above examples all involve some quantitative concepts, such as "there are only a few", "many", "most", "at least half", "at least five" and so on. The first four quantifiers can't be expressed with the help of universal quantifiers and existential quantifiers, but the last quantifier needs to add the word "inequality": "existence x1, …, x5 makes them unequal to each other", which can't be expressed only with existential quantifiers. Therefore, using the methods provided by Frege and Tarski, to study the structure of these quantifiers, we must adopt a new artificial language, and its interpretation should conform to our intuitive understanding of these quantifiers. Polish logician Mostovski put forward the theory of generalized quantifiers in 1957, which deals with these quantifiers specially [9]. This logic theory is of great significance to the development of language theory.

By comparing the previous analysis of expressions such as "existence" or "there is a..." in everyday language, we can see that the expression of existence is essentially a quantitative expression. From the point of view of true value, it means that there is at least one. In daily expression, the word "existence" can be used or not. In other words, there are various ways to express existence. In addition, in grammatical form, the word "existence" can express common nouns, descriptions and names. But syntactically, it is a quantifier and an expression higher than a predicate. Semantically, it represents a specific object in an individual domain. Whether a sentence expressing existence is true or not depends on whether the concept expressed by the predicate is suitable for a specific thing in the individual domain. Therefore, many people believe that the work of existence is served by quantifiers [10].

Under Frege's theoretical framework, quantifiers are treated as second-level concepts [11]. Frege distinguishes two types of entities: objects and functions. Objects are complete things, while functions are incomplete things. The names represents the object, which is complete; Predicates represent concepts, which are incomplete. A proper name adds a predicate to get a sentence, and an object adds a concept to form a truth value, which is what the sentence represents. What about quantifier components in sentences? In Frege's view, quantifier belongs to the second-level concept, and its complement is predicate. The semantics of predicates represent a specific class or set, so the semantics of quantifiers represent a set composed of sets. The interpretation of universal quantifiers is a collection composed of the whole individual domain, while the interpretation of existential quantifiers is a collection composed of non-empty subsets of individual domains. According to this model, almost all quantifiers can be explained, which shows that Frege's theory really provides a method to explain the semantic function of classifiers in natural language.

The core issue of linguistics is to explain the common things in all natural languages and why a natural language has developed into its present form instead of other possible forms. We give some simple examples to explain why the generalized quantifier theory is useful for linguistic research. There are noun phrases in every natural language, including names, common names and noun phrases formed by modifying components; It also includes some qualifiers in language, such as every, some, all and so on; If a language contains articles (such as English), it also belongs to noun phrases. From the perspective of generalized quantifiers, these can be regarded as generalized quantifiers. As a quantifier, names semantically refer to a specific individual. Common names are also quantifiers, which delimit a range of objects. Articles and determiners belong to the scope of generalized quantifiers. However, even as generalized quantifiers, these words have different semantic functions in different languages and even in different contexts of the same language. Logicians provide various logical theories about the use of these words [12].

When studying the quantification of natural language from the semantic point of view, the basic problem is that the category of quantifiers is very rich. For example, there are 2^{16} different binary quantifiers in the discourse domain with two elements, but we only see a few binary quantifiers in natural language. This brings us back to the question we pointed out earlier, why only a small number of quantifiers have been developed in the domain of discourse with two individuals in natural language? What are the functions of qualifiers in natural language? Under these restrictions, which quantifier properties are valid? This is not only the problem of linguists, but also the problem of logicians, but the research methods are different [13]. In order to find out the real situation of natural language, linguists can use the method of statistical analysis, while logicians provide a formal explanation for language phenomena, such as describing binary quantifiers seen in natural language semantically.

6. Conclusion

Linguistic research on natural language can enrich logic theory and provide resources for the development of logic theory. On the other hand, logic theory can provide theoretical support and explanation methods for language research. When using semantic theory to explain language phenomena, such as restrictions on various syntactic

constructions and explanations of expressions in a certain category, abundant research results can be obtained.

Quantifiers can help people express and describe. Because quantifiers can limit the scope of expression and description, so as to provide help for the expression and understanding of their condition of truth value. With the help of quantifiers, in some cases, we can judge whether the expression and description is true or not. In some cases, although we can't make a judgment, we can explain the condition of its truth value. With the help of the nature and function of quantifiers, we can get a lot of very important knowledge, especially about ontology and epistemology. Therefore, the role of quantifiers is very important.

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