

Chinese Studies on the Logic of Natural Language—A Survey from 1949 to 2019

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Abstract

This paper makes a historic review on the development of the Logic of Natural Language (LNL) in China, which can be roughly divided into three periods: the first period which spanned from the late 1950s to the late 1980s was the initial period of LNL in China; the second period, a transitional period from the preliminarily integrated mode of LNL to the deeply integrated mode of LNL, lasted for the whole decade of the 1990s; the third period was from 2000 on, and during this period the deeply integrated mode became the mainstream of LNL. In today's China, LNL is not only an important research field of logic, but has also exerted a great impact on linguistic studies and the studies in the field of natural language processing (NLP).

Keywords: logic of natural language (LNL), preliminarily integrated mode, deeply integrated mode

Kitajske raziskave logike naravnega jezika – pregled razvoja od 1949 do 2019

Izveček

Članek podaja zgodovinski pregled razvoja logike naravnega jezika (LNJ) na Kitajskem, ki ga je mogoče v grobem razdeliti na tri obdobja: prvo, ki se razteza od konca 50. do 80. let 20. stoletja, predstavlja obdobje začetkov LNJ na Kitajskem; drugo, obdobje prehoda od preliminarno integrirane oblike LNJ h globoko integrirani LNJ, je trajalo skozi celotna 90. leta 20. stoletja; tretje, ki traja od leta 2000 dalje, pa predstavlja čas, ko je globoko integrirana LNJ postala osrednja struja raziskav LNJ na Kitajskem. Na tem mestu je treba tudi poudariti, da LNJ v današnji Kitajski ne predstavlja zgolj enega od pomembnih področij raziskovanja logike, ampak je to polje prav tako pomembno vplivalo na kitajske jezikoslovne raziskave in preučevanje obdelave naravnega jezika (ONJ).

Ključne besede: logika naravnega jezika (LNJ), preliminarno integrirani način, globoko integrirani način

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Introduction

Logic is defined as the theory of right thinking and successful communication in Zhou Liquan (1994), and the Logic of Natural Language (LNL) is generally understood as the study of logic problems of natural languages (Chen Daode 2005, 97). However, due to the complexity of natural language (NL) and the special relation between logic and language, it is far from enough to treat LNL as simply a matter of “logic plus NL”. Since the understanding of NL itself is based on deduction under the guidelines of LNL, there are two types of deduction involved in LNL: extralinguistic and intralinguistic. The former refers to the deduction via NL while the latter refers to the deduction concerning the construction of NL, which makes it possible that the compositional expressions are syntactically and semantically derived/inferred from their constituents. Accordingly, there are two modes of LNL. One is to develop the logic theories aiming at the formal representation of some isolated phenomena of NL, say, presupposition and implicature, but the syntactic structure of NL is not the concern of the study. Typical examples of this mode include speech act theory and the cooperative principle of conversation. The other one is to develop the formal theories aiming at the formal representation of the syntactic generation and semantic composition of NL. The typical theories of this mode include various categorical grammars, Montague grammar, discourse representative theory, and so on (cf. van Benthem and ter Meulen 2011). In this paper, the former mode is called preliminarily integrated mode between logic and linguistics, while the latter is called deeply integrated mode.

Therefore, LNL can be understood either in its broadest sense or in its strictest sense. In its broadest sense, it covers both preliminarily integrated and deeply integrated modes. In its strictest sense, it only refers to the latter mode. In this paper, LNL is used in its broadest sense. In China, the preliminarily integrated mode of LNL was initiated as early as the late 1950s, which is marked by Zhou Liquan’s proposal to develop the logic theory of thinking and communication via NL, a theory similar to Austin’s speech act theory. However, his work was interrupted by the Cultural Revolution, the political catastrophe in China that lasted from 1966 to 1976, and it is not until the end of the 1970s that Zhou Liquan 周礼全 (1921–2008) and his fellow researchers restarted their preliminarily integrated studies of LNL. The other influential scholars in this field include Wang Weixian 王维贤 (1922–2017), Li Xiankun 李先琨 (1926–2017) and Chen Zongming 陈宗明 (1934–), known as the Triangle of the Pioneers of LNL in China, and Cai Shushan 蔡曙山 (1950–), a doctoral student of Zhou Liquan.

The deeply integrated mode of LNL was introduced into China in 1992. During this year, Zou Chongli 邹崇理 (1953–), another doctoral student of Zhou

Liquan, finished his doctoral dissertation *Montague Grammar and its Tentative Application in Semantic Analysis of Mandarin Chinese*, the first paper on the deeply integrated studies of LNL in China. Since the beginning of the 21st century, the deeply integrated mode of LNL has gradually become the mainstream of LNL in today's China.

Roughly speaking, the development of LNL in China can be divided into three major periods: 1) The period from the late 1950s to the late 1980s was the initial period of LNL in China, and during this period studies of LNL were mainly made in the preliminarily integrated mode. 2) The whole decade of the 1990s was a transitional period characterized by the parallel development of the preliminarily integrated mode and the deeply integrated mode. 3) The period from 2000 on has been the all-round development period, during which the deeply integrated mode has gradually become the mainstream mode of LNL, and LNL has also become one of the important interdisciplinary fields between logic, linguistics and NLP.

Initial Period (The Late 1950s–1980s)

The period from the late 1950s to the late 1980s can be viewed as the initial period of LNL in China. Due to the interruption of the Cultural Revolution, this initial period lasted for more than 40 years, and 1979 can be viewed as an epoch-making year for LNL in China. On March 4, 1979, there were 25 logicians from 21 initiative institutes across China gathering in the city of Guilin to announce the establishment of the China Association of Logic and Language (CALL). In August 1979, when the establishment of the Chinese Society of Logic (CSL) was announced during the First National Symposium on Logic held in Tongxian, Beijing, CALL was approved as a branch of CSL.

This initial period is characterized by the preliminarily integrated mode of LNL. Actually, during the late 1950s when Austin began to sketch the theoretical framework of speech act theory, Zhou Liquan, the father of LNL in China, put forward a similar theory independently (Zhou Liquan 1961, 2000). In 1958, Zhou Liquan proposed that “reasoning, under the usual conditions, always goes on in a NL. Therefore, the application of formal logic must be done in natural language with which more logic knowledge can be taught to students” (see Zhou Liquan 2000: Preface), and thus formal logic can be studied for and in NL. In 1961, Zhou Liquan published his paper “Formal Logic should be Applied in the Study of the Meaning of Natural Language” which can be viewed as the birth of LNL in China. In this paper, he proposed that: 1) There are three types of meaning of NL: declarative meaning which expresses what is in the world; attitude

meaning which expresses the speaker's attitude toward what is in the world, and causative meaning which causes the addressees to act. 2) Meaning is externalized in the specific context which consists of time, place, addressor/addressee, and what has been expressed previously and what are anticipated to be expressed. 3) It is important to include the grammar and rhetoric devices into the study of formal logic. 4) It is necessary to establish a new logic system, i.e., the logic system of NL, by enriching the basic logic terms. Looking at this list, 1) bears great similarity to Austin's speech act theory, while 2) and 3) are similar with the Gricean theory of implication (Cai 2002).

Under the influence of Zhou Liquan, the first group of Chinese scholars engaging in the studies on LNL came into being, represented by Wang Weixian, Li Xiankun and Chen Zongming. After nearly ten years of stasis due to the Cultural Revolution, the study on LNL in China lagged far behind. For this reason, when work on LNL restarted at the late 1970s, the main task of Chinese scholars during the 1980s was to introduce various theories of LNL into China and analyse Mandarin Chinese from point of view of logic in a non-formalized way.

During this period, most of the influential papers on LNL were published in *Logic and Language Learning* (*Luoji yu yuyan xuexi* 逻辑与语言学习), a bimonthly journal founded in 1980 by CALL, and four volumes of *Studies on Logic and Language* (*Luoji yu yuyan yanjiu* 逻辑与语言研究) edited by CALL successively from 1980 to 1989, as well as the symposiums of *Theses on Logic and Language* (*Luoji yu yuyan lunji* 逻辑与语言论集) and *New Theses on Logic and Language* (*Luoji yu yuyan xinlun* 逻辑与语言新论) edited by CALL in 1986 and 1989 respectively. The representative papers on LNL include "Brief Introduction to Tense Logic" (*Tantan shitai luoji* 谈谈时态逻辑, 1981) by Zhang Jialong 张家龙 in *Studies on Logic and Language* (vol. 1); "On Contrast (*Lun zhuanzhe* 论转折, 1982) by Wang Weixian and "Relational Logic and Everyday Conversation" (*Guanxi luoji yu richang yuyan* 关系逻辑与日常语言, 1982) by Zhuge Yingtong 诸葛殷同 in *Studies on Logic and Language* (vol. 2); "On the Object of Language Logic" (*Shilun yuyan luoji duixiang* 试论语言逻辑的对象, 1986) by Ma Pei 马佩 (1929–2014).

The most important monographs published during this period include *Introduction of Language Logic* (1989) co-authored by Wang Weixian, Chen Zongming and Li Xiankun, *Brief Studies on the Logic of Modern Chinese* (1979) and *Logic and Expressions of Language* (1984) by Chen Zongming. *Fundamentals of Language Logic* (1987) edited by Ma Pei, *Logical and Verbal Communication* by Sheng Xinhua 盛新华, and *Art of Language Communication: The Logic Function of Context* (1989) by Wang Jianping 王建平.

Transitional Period (1990s)

In the 1990s, the research on LNL entered a new stage of development. This period is characterized by the transition from the preliminarily integrated studies of LNL to the deeply integrated studies. On the one hand, Zhou Liqun finished his “four-layer” theory of meaning (Zhou Liqun 1993, 1994) which represents the summit of the preliminarily integrated studies of LNL in China. On the other hand, it is during this period that the deeply integrated mode of LNL was introduced into China and gradually accepted by Chinese scholars represented by Zou Chongli, a doctoral student of Zhou Liqun.

In the preliminarily integrated mode of LNL, logic theories such as truth conditional semantics, propositional logic, tense logic, first order logic, etc. are employed to give account of the deductions expressed or expressible in NL. Since the linguistic mechanism underlying NL is not the concern of LNL, the study of this mode usually could not give birth to new theories specifically for the logical account of NL. In contrast, the deeply integrated studies of LNL aims at the formalization of the working mechanism which accounts for the ways NL works, or more exactly, the study of this mode is to construct the formalized representation of the syntactic and/or semantic structure of NL. Since the “pure” logic theories are inadequate in accounting for semantically/syntactically/textually mechanism of NL due to the complexity of NL, logicians in the deeply integrated mode have to develop various new theories interdisciplinary between logic and linguistics to cope with the problems of NL, such as Montague Grammar (MG), Generalized Quantifier Theory (GQT), Discourse Representative Theory (DRT) and Categorical Type Logic (CTL). All of these were introduced into China during the 1990s.

Zhou Liqun and Cai Shushan: Preliminarily Integrated Studies of LNL

In 1993 Zhou Liqun published his paper “Formal Logic and Natural Language”, which was a lecture delivered at China’s First National Seminar on Logic in May 1978. In this paper, Zhou Liqun proposed that the sympathetic meaning is an important aspect of meaning in NL. Based on this point and following the insights of various meaning theories such as referential theory, ideational theory, behaviourist theory, and use theory, Zhou Liqun developed his “four-layer” theory of meaning, which is based on the basic concepts such as meaning, context, implicature and presupposition. His theory can be outlined as follows: there are four layers in the conventionally understood concept of meaning: *A* (standing for a proposition) expressed by an abstract sentence;

FA (representing “proposition + propositional attitude”) expressed by a sentence¹; $U(FA)$ expressed by the utterance of a sentence in which U represents the speaker’s emotional attitude, and $C_R^*(U(FA))$ is what a speaker intends to express in a specific context C_R .

Zhou Liquan systematically presented his theory in *Logic: The Theory of Correct Thinking and Effective Communication*. This book, a landmark work in China’s history of LNL, was edited by Zhou Liquan, with its contributors being the most distinguished Chinese scholars in LNL at that time. Apart from Zhou Liquan’s theory of meaning which covers implicature, presupposition, context and speech act, this book gives a systematic introduction to the various formal logic theories involved in LNL. Even today, this book still exerts a great impact on LNL researchers in China.

Following the footsteps of Zhou Liquan, Cai Shushan, one of his doctoral students, devoted himself to the study of illocutionary logic. From 1996 to 2002, he developed his own formal theory of illocutionary logic (Cai 1996; 1997; 1999; 2002). In 1998, he published the monograph *Speech Act and Illocutionary Logic* in which he systematically presented his formal theory of illocutionary logic.

The other representative achievements of the generalized studies of LNL during this period include: *Pragmatic Logic and Semantics* (1994) edited by the Chinese Association of Logic, *Logic of Language and Verbal Communication* (1991) by Hu Zehong, and *Studies on General Expression in Mandarin Chinese* (1998) by Xu Songlie 徐颂列. In 1992, *Introduction to Chinese Logic* was published. It is one of the noteworthy fruits of the Salon of Language Logic. The Salon, its main topic being the logical aspect of NL, was initiated in 1987 in Hangzhou, with the participants mostly being young scholars from various universities in Zhejiang Province.

Zou Chongli: Deeply Integrated Studies of LNL

It is during the 1990s that the deeply integrated mode of LNL was introduced into China. In 1992, Zou Chongli, a pioneer of the deeply integrated studies of LNL in China, finished his doctoral dissertation *Montague Grammar and its Tentative Application in Semantic Analysis of Mandarin Chinese*, the first paper on this grammar in China. During the same year, *Studies on Logic Semantics* edited by Zhu Shuilin 朱水林 was published. This book, a collaborative work of nine

1 Note that the term of “propositional attitude” is used in the sense of illocutionary force by Zhou Liquan (1994).

scholars from philosophy, logic, linguistics and computational science, was a comprehensive guide to the basic theories of logic semantics developed along the lines of G. Frege, A. Tarski, P. R. Carnap and R. Montague. In 1995, Zou Chongli published his first monograph, *Logic, Language and Montague Grammar*, the first Chinese book systematically introducing Montague Grammar.

Following the insights of categorical grammar and Montague Grammar, various formal theories that were interdisciplinary between logic and linguistics, represented by CTL, GQT, and DRT, among others, were developed to cope with compositional aspect of NL. Compared with those classic logic theories, these theories of natural language were more flexible and effective in formalizing the syntactically and semantically compositional mechanism of NL, as well as the pragmatic reasoning of NL. For instance, the principle of syntax-semantics correspondence, the rule of thumb in the formal treatment of NL, is theoretically captured in CTL. Generalized quantifier theory revolutionized the concept of quantifier in the studies of NL, and hence greatly improved the expressive power of logic theories to formalize the complex and multifarious quantificational phenomena of NL. DRT and the other theories of dynamic semantics aim at capturing the dynamic construction of meaning. Therefore, the deeply integrated theories of LNL are more applicable in NLP, and thus represent the trend of development of LNL.

However, due to the lost ten years of the Cultural Revolution, the deeply integrated studies of LNL in China lagged far behind. Towards the end of the 1990s there were only a few doctoral students who, under the influence of Zou Chongli, began to turn their interest to the deeply integrated studies of LNL, and the deeply integrated mode of LNL in China was still in its challenging early stage.

All-round Development Period (Since 2000)

Since the beginning of the 21st century, the study of LNL in China has entered a new period of all-round development. In today's China, the deeply integrated studies of LNL have gradually become the mainstream of LNL, and the gap between the research on LNL inside and outside of China has been greatly narrowed down. At present, there are two main circles of LNL: the Chinese Academy of Social Sciences (Zhongguo shehui kexueyuan 中国社会科学院, CASS) and Zheda (Zhejiang daxue 浙江大学 Zhejiang University). The CASS Circle is known for its deeply integrated studies of LNL, and its research is mainly on the syntactically and semantically compositional aspects of NL. In contrast, the research focus of LNL in the Zheda Circle is mainly on the logical aspects of

metaphor, presupposition, argumentation as well as the pragmatic reasoning of NL. Additionally, there are also some logicians in other universities (for example Sun Yat-sen University (Zhongshan daxue 中山大学) and Nanjing University (Nanjing daxue 南京大学)) whose research cover the field of LNL.

At present, LNL is one of the hottest fields in logic studies. Since 2010 when the National Social Science Fund of China (NSSFCC) began to fund the Major Research Programs of Fundamental Sciences, Zou Chongli, Huang Huaxin 黄华新, Cai Shushan, Du Guoping 杜国平, and others have successively been approved to implement different Major Research Programs on LNL funded by the NSSFCC. Additionally, every year there are always some special programs on LNL approved by NSSFCC.

CASS Circle of LNL

The CASS Circle of LNL refers to a group of scholars most of whom finished their doctoral or post-doctoral studies in CASS. Zou Chongli, as the pioneer of the deeply integrated mode of LNL in China, is the leading scholar of the CASS Circle.

The studies produced by the CASS Circle cover MG, GQT, DRT, Situational Semantics and Event Semantics, among other topics. Since 2000, Zou Chongli has published the monographs *Studies in Natural Language Logic* (2000), *Logic, Language and Information: Studies in Logical Grammar* (2002) and *Categorical Type Logics* (2008). Additionally, he has authored or co-authored more than 100 papers on LNL. Stimulated by Zou Chongli's work, many young scholars are working in various fields of LNL, and remarkable achievements have been made over the past twenty years. Representative works include: Liu Xinwen's 刘新文 doctoral dissertation *Quantity Extension of System Z and its Treatment of DRT* (2002), Li Kesheng's 李可胜 doctoral dissertation *Model and Computation of Events* (2010), Zhang Xiaojun's 张晓君 doctoral dissertation *Studies on the Properties of Generalized Quantifiers* (2011), Gao Yun's 高芸 doctoral dissertation *Exploring the Rhetorical Form of Chinese Discourse Structure from the Angle of SDRT* (2011), Jia Guoheng's 贾国恒 monograph *A Research on Situational Semantics* (2012), and Chen Linlin's 陈琳琳 doctoral dissertation *A Research on Chinese Donkey Sentences Based on the Framework of DRT* (2013).

From around 2010, a team of researchers under Zou Chongli's leadership devoted themselves to studies on the application of CTL in NLP, especially the application of Combinatory Categorical Grammar (CCG) in analysing large-scale authentic texts of Mandarin Chinese. Accepted as one of the most efficiently

parseable and linguistically adequate grammars of NL, CCG is known for its theoretical parsimony and strong adequacy. Since 2010, Zou Chongli has been approved to implement two major research programs on LNL funded by NSSFC. Working collaboratively with computational linguists, the research team led by Zou Chongli has created an experimental CCG-based Chinese TreeBank. The relevant works can be found in *Logical Semantics on Natural Language Processing* (2018), as well as in Chen Peng's 陈鹏 postdoctoral report *Research on CCG and Construction of Treebank of Chinese* (2016).

The other notable achievements made by the CASS Circle in categorial grammar include: Wang Xin's 王欣 doctoral dissertation *Categorial Type Logics and "shi" and "de" in Mandarin Chinese* (2009), Zhang Lu's 张璐 doctoral dissertation *Category Grammar of Mandarin Chinese Structure of "Adjective + Noun"* (2013), Man Haixia's 满海霞 monograph *Typical Logic Studies on Anaphora and Ellipsis in Mandarin Chinese* (2014), Jia Qing's 贾青 monograph *Categorial Type Logics and Their Application in Anaphora of Pronoun in Mandarin Chinese* (2015), Shi Yunbao's 石云宝 doctoral dissertation *A Study on DRT Based on Compositionality* (2015) and Yao Congjun's 姚从军 paper "IT-oriented Analysis on Chinese Pronoun Anaphora Phenomenon from the Perspective of CCG" (2018).

Zheda Circle of LNL

In the south of China, Hangzhou 杭州 in Zhejiang Province has become another centre of LNL studies. Huang Huaxin, a distinguished professor at Zhejiang University, is the leading scholar of the Zheda Circle of LNL. Following the footsteps of Wang Weixian and Chen Zongming, the research on LNL in the Zheda Circle mainly covers the formalized studies of metaphor, presupposition, argumentation and pragmatic reasoning.

Since 2007, Huang Huaxin has been working as one of the chief-editors on *Library of Linguistics and Cognition* (in 16 volumes), *Studies in Linguistics and Cognition* (in six volumes), and *Translated Library of Linguistics and Cognition* (in 10 volumes). Additionally, he has authored or co-authored more than 60 papers on formalized studies of the semantics and/or pragmatics of NL. The most representative papers include: "Aspects of Pragmatic Referentiality" (2010, with Chen Jing), "Communicative Acts: Intentionality, Contextuality and Reciprocity" (2012, with Wu Yicheng), "An Ontology-Based Approach to Metaphor Cognitive Computation" (2013, with Huang Xiaoxi et al.), "Partial Semantics of Argumentation: Basic Properties and Empirical Results" (2013, with Liao Beishui et al.), "Metaphor Interpretation and Motivation in Relevance Theory" (2014, with Yang Xiaolong),

and “The Expression and Understanding of Metaphors from the Perspective of Cognitive Science” (2020).

Other representative achievements made by the Zheda Circle of LNL include the monographs of *Logical Analysis of Chinese Sentences* (2011) by Jin Li 金立, *Formal Analysis of the Meaning of Mandarin Chinese Sentences* (2011) by Chen Zongming and others, and Jia Gaiqin’s 贾改琴 doctoral dissertation *Epistemic Predicate Logic System KSS+KBF* (2007).

Achievements of Other Scholars

The past twenty years have witnessed the rapid development of LNL in China. The scholars who engage in the study of LNL include not only those mentioned above, but also scholars whose research interest covers LNL. In Sun Yat-sen University, some scholars working at ILC (the Institute of Logic and Cognition) are also making remarkable achievements in studies of LNL. For instance, the book of *Logic of Natural Languages for Knowledge Representation and Reasoning* (2009) edited by Ju Shier 鞠实儿 can be viewed as one of the most important Chinese books on LNL. Other important works by the scholars in ILC include “Research of Flexible Word Order in Chinese Statements Based on Light Weight Semantic λ -calculus” by Liu Dongning 刘冬宁 et al. (2016), and “On Logical Analysis of Evaluating a Real Argument in Everyday Life” by Xiong Minghui (2006).

In Beijing, though Cai Shushan has turned his interest to the interdisciplinary field between LNL, cognitive studies and psychology, his work on LNL cannot be ignored. During the past two decades he has published more than 60 papers, and most of them are on LNL. His recent representative work on LNL is the book of *Formal Theories of Natural Languages* (2010, co-authored with Zou Chongli). Zhou Beihai 周北海, a professor at Beijing University, has been working on the properties of the generic sentence and the problems of its reasoning. His representative works include “Four Semantic Layers of Common Nouns” (2010, with Mao Yi), “A Tableau Algorithm for Term Logic of Generic Sentences” (2013, with Ma Li 马丽), and “A Formal Characterization of Referential Presupposition: Triggered by Proper Names as Existence” (2014, with Fu Qingfang 傅庆芳). Other noteworthy achievements made by scholars in Beijing include Liu Zhuanghu’s 刘壮虎 paper “Entailment and Conditional Entailment, Among Others” (2004) and Du Guoping’s paper “A ‘not...but...’-Type Natural Deduction System Without Connectives” (2019).

Apart from those mentioned above, there are various other achievements in LNL made by Chinese scholars during the past two decades, such as the papers

“Connection from Mental Content to Meaning” (2018) and “The Problem of Predication in Russell’s Philosophy and its Cognitive Significance” (2015) by Huo Shuquan 霍书全, “Two-dimensional Presuppositional Logic and The Projection of Presupposition in Compound Sentences” (2008) by Deng Xiongyan 邓雄鹰 and Hu Zehong 胡泽洪, “The Logical Features of Metaphor” (2007) by An Jun 安军 and Guo Guichun 郭贵春, and “The Idealization in Metaphorical Modelling and its Logical Characteristics” (2018) by Yang Yeyang 杨焯阳 and Guo Guichun.

Interdisciplinary Studies of LNL

Following the trends in LNL around the world, LNL has not only become one of the important fields of logic studies in China, but also one of the important interdisciplinary fields between logic, linguistics and NLP. More specifically, there are an increasing number of scholars in linguistics and NLP who adopt the formal theories of LNL in their study of NL.

Due to the fact that Mandarin Chinese, as a typical language of parataxis, is poor in morphological markers, and the rules of expressions are highly sensitive to semantic and/or pragmatical factors, there is a tradition in Chinese linguistics to analyse Mandarin Chinese from the logical point of view. Actually, an older generation of linguists such as Wang Li 王力 (1900–1986), Lü Shuxiang 吕叔湘 (1904–1998), Zhu Dexi 朱德熙 (1920–1992), Guo Shaoyu 郭绍虞 (1893–1984), and Zhang Zhigong 张志公 (1918–1997), thought highly of logical approaches to linguistic studies. Among these scholars, Wang Weixian, a distinguished linguistic professor in Zhejiang University, is one of pioneers of LNL. The other representative scholars include Xin Fuyi 邢福义, a linguistics professor in Central China Normal University, and Yuan Yulin 袁毓林, a linguistics professor in Beijing University.

As early as 1984, *Logic in Linguistics*, a famous textbook of LNL written specially for linguists by J. Allwood et al., was translated into Chinese. However, the earlier study of LNL in linguistics was limited to the adoption of proposition logic or first-order logic in locally accounting for some semantic or pragmatic phenomena in Mandarin Chinese. It is under the influence of Chomsky’s theory of transformational syntax and Montague Grammar that the logical aspect of the global mechanism of NL became the main concern of formal semantics for those linguists. In 1998 and 2000, *Introduction to Formal Semantics* by Jiang Yan 蒋严 and Pan Haihua 潘海华, two scholars from Hong Kong, and *Logic Semantics: An Introduction* by Fang Li 方立 (1942–2010), were both published. These are the

earliest Chinese books on formal semantics published by and for linguists, playing a very positive role in popularizing the formal semantics in China.

Since the beginning of the 21st century, more young scholars have entered the field of formal semantics. Representative publications on formal semantics from these years include Li Kesheng's paper "Generative Models of SVC's Semantics and Their Triggering Conditions" (2020), the article "On the Logical Nature of Pragmatic Inference" (2002) by Jiang Yan, *Research on Type-logical Grammar* (2007) by Zhang Qiucheng 张秋成, *Introduction to Event Semantics* (2017) by Wu Ping 吴平 and Hao Xiangli 郝向丽, and *Approaching Formal Pragmatics* (2011), edited by Jiang Yan. In particular, since Jiang Yan published his paper "On the Logical Nature of Pragmatic Inference" in 2002, studies on the scalar implicature brought about by the Mandarin Chinese words *dou* 都, *ye* 也, and others, have been one the hottest topics in Chinese linguistics, and there are a large number of papers on this theme. Among them, the most representative include "Focus-sensitive Constructions and the Interpretation of Focus (I/II)" (2003) by Lee Po-lun Peepina, and others, "De-construction, Modality and Counterfactual Reasoning" (2016) by Lin Jo-wang 林若望, and "Revisiting the semantics of *dou*" (2018) by Feng Yuli 冯予力 and others.

In recent years, a group of young scholars who obtained their doctorates in overseas universities published their research papers in international journals, which has greatly raised the reputation of China's formal semanticists. Representative papers among these include Lin Jo-wang's "Choice Functions and Scope of Existential Polarity WH-phrases in Mandarin Chinese" (2004) in *Linguistics and Philosophy*, "On the Semantics of Comparative Correlatives in Mandarin Chinese" (2007) in the *Journal of Semantics*, and Liu Mingming's 刘明明 paper "Varieties of Alternatives: Mandarin Focus Particles" in *Linguistics and Philosophy* (2016). Additionally, Liu Mingming also published his English monograph *Varieties of Alternatives: Focus Particles and wh-expressions in Mandarin* (2018).

In NLP, Feng Zhiwei 冯志伟, one of the most distinguished computational linguists in China, wrote a paper titled with "Categorial Grammar" to introduce the application of categorial grammar in NLP as early as 2001. Since then, categorial grammar and its variants (especially CCG) have been gradually introduced into the field of NLP.

In CCG, there is a completely transparent interface between surface syntax and underlying semantic representations including the predicate-argument, quantificational and informational structure of NL. The lexicon becomes the only resource for specifying language-specific information such as the order of constructions, and the syntactic projection of NL is defined by a small set of combinatory

rules. Thus it is viewed as one of most effective tools of modelling the close coupling between syntax and semantics envisaged in MG and its modern variants. The advantages of CCG make it easily adopted to the common practice of NLP, and thus it has been one of the most important logic theories applied in NLP. The same is true in China, and there is an increasing number of Chinese scholars of NLP who adopt CCG in NLP. A CCG treebank created from the Tsinghua treebank by a team led by Song Yan 宋彦 (Song Yan et al. 2012; Zhou Qiang 2016) can be viewed as the most influential work of this type in China during the last twenty years.

Other important work on of CCG in NLP can be found in papers such as “Study on the Formalization of Information Processing-oriented Context” (2004) by Li Dehua 李德华 and Liu Genhui 刘根辉, “Metaphor Literal Meaning Representation and Generation” (2009) by Wang Jinjing 王金锦 et al., “Measuring Word Abstractness for Metaphor Recognition” (2017) by Jia Yuxiang 贾玉祥, and Rekia Kadari’s doctoral dissertation *CCG Supertagging Based on Deep Learning Models* (2018).

Conclusion

On the whole, LNL in China experienced an incredibly prolonged initial period from the end of the 1950s to the end of the 1980s, a very challenging period of development during the whole 1990s, and an accelerated and comprehensive development during the first twenty years of 21st century. After more than half a century’s development, LNL in China has made great progress. Today, it has not only become one of important research fields of logic, but also an important interdisciplinary field linking logic, linguistics and NLP.

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