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A Review of the Research on Cognitive Mechanism of the Processing of Chinese Negative Sentences

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Abstract: *Negation is an essential concept in human languages. Traditional studies of negation were focused on the analysis of its structure and function. In recent years, the research on the processing of Chinese negative sentences had been in the ascendant. Based on the extant literature, this paper first generalized a series of related theories about negative processing, and then analyzed the four influencing factors of the processing of negation as follows: types of negative sentences, context, emotion and individual differences. Finally, it pointed out that more attention should be paid to expanding the research objects, conducting the second language studies of the negative sentence processing, and integrating new experimental methods in future research.*

Keywords: *negative sentences, cognitive mechanism, language processing*

1. Introduction

Negation is one of the most essential thinking modes of human kind. The expression of the concept of negation has attracted close attention from linguists, logicians, metaphysicians and philosophers since Plato and Aristotle (Horn, 2001). In recent years, there was a tendency to be interdisciplinary in the research on negation due to not only the complexity of its processing but also the continuous debate on the mental mechanism. The analysis of the negation at the syntactic and semantic level has gradually transformed into the comprehension or production of the negation of human beings.

According to the related literature, the research on the cognitive mechanism of the processing of Chinese negative sentences can be classified into four dimensions. Firstly, the online processing of negation is varied by the types of negative sentences (Mayo et al., 2004; Li et al., 2017; Zhao et al., 2014). Secondly, the modulation of the context plays an important role in the negative processing (Chen et al., 2014a, 2014b, 2018). Thirdly, the processing of emotional words can be interfered with by the negative sentence form for negation is always intertwined with emotion (Jiang et al., 2014, 2018; Gao et al., 2019). Fourthly, the study of individual differences has gradually received attention (Feng et al., 2020). As mentioned above, however, it is still very hard to clarify the essence of processing of negation and related research on Chinese negative sentences remains relatively insufficient at the moment.

In view of this, this paper combed the research literature to enumerate the related theories of the processing of negation. Then it analyzed the influencing factors of the negative processing on the basis of the theories. In the end, some future directions were put forward in order to bring enlightenment to domestic research in this field.

2. Overview of Negative Sentence Processing Theory

The traditional studies of negative sentences have been mainly influenced by structuralism that puts emphasis on the formal description of language structure, which is separated from the subjects of language use. In this regard, the essence of negation had been not penetrated until the 1960s and 1970s that psychologists began to use a large number of psychological research paradigms to explore the online processing mechanism of negative sentences from a cognitive perspective. By its very nature, the construal of sentence meaning is based on framework from the perspective of cognitive linguistics. Framework has a significant influence on the comprehension of the negation. According to Lakoff (2004), a framework is in essence triggered although it is negated. In other words, the negated state of affairs would be at first activated and then the actual meaning of the sentence would be comprehended.

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The usage of negation in those political speeches provides a crucial path to analyze how the mind can be manipulated by language. Therefore, it is necessary and crucial to clarify the mental mechanism of negative processing.

However, the processing mechanism of negative sentences has been heatedly debated in the field of psychology. In fact, there are two research paths traced by mental processing of negative sentences: One is the propositional theory (Kintsch & van Dijk, 1978) and the other is the experiential-simulations view (Barsalou, 1999). It stands to reason that the above two theoretical models are respectively supported by empirical evidence. The propositional theory holds that linguistic signs are arbitrary and have no corresponding relationship with the physical experience and the perceptual state of human beings. In view of this, language comprehension indicates the corresponding propositional representation can be constructed. Under the influence of the first generation of cognitive science, negation can be represented explicitly and is regarded as a special symbol of mental representation and an abstract logical operator. Its operating rule is to express the opposite meaning that is contrary to the meaning of its domain (Gao & Lu, 2009). The experiential-simulations view emerged in the second generation of cognitive science. Influenced by the embodied cognition theory of this period, it is believed that language comprehension is actually a process in which people construct mental models based on their existing experiences and simulate the described content and situation a second time while reading a text. Negation as a semantic logical operator can only be represented implicitly (Cui et al., 2016). On the basis of embodied cognition, Kaup et al. (2007) proposed a Two-Step Simulation Hypothesis of the negative processing. According to the theory, the negative processing can be divided into two steps: At first, the negative meaning of semantic content is constructed through mental simulation in the first stage; then the negative meanings begin to be inhibited at the second step. For instance, a speaker will be hard not to think about a tiger while processing the sentence “It is not a tiger.” at the first step. And then the real sense can be comprehended completely with the advance of processing. Nevertheless, the essence of negative sentence processing has been inconclusive till now. In this regard, researchers have been exploring some new approaches to integrate propositional theory and experiential-simulations view such as the Dual-Coding Theory (Paivio, 1971), the LASS Theory (Barsalou, 1999), the Symbol Interdependency Hypothesis (de Vega et al., 2008; Louwerse & Jeuniaux, 2008) and so on. On that basis, Gao et al. (2017) put forward the Suppression-Reactivation-Resuppression Theory of negative sentence processing. According to the theory, when processing negative sentences, the negated information is unconditionally suppressed at first and then simulated conditionally before its real sense is activated in the final. In a word, the controversy about its processing mechanism mainly originates from the complexity of the negation and the setting of experimental tasks.

In addition, with the prosperity of cognitive science, researchers have also been gradually turning to explore the neural mechanism of negative sentence processing in the brain. In cognitive neuroscience, such brain imaging techniques as Event-Related Potentials (ERPs), functional Magnetic Resonance Imaging (fMRI) and Positron Emission Computed Tomography (PET) are used to investigate its cognitive processing so as to contribute to the modification of the preexisting theories and models and put forward new theories and models on this basis (He et al., 2013).

3. Influencing Factors of Negative Sentence Processing

3.1 Types and Properties of Negative Sentences

It stands to reason that negation is indispensable in language communication. As the concrete forms of the negation, the negative words are always inserted into the sentences to be expressed. Theoretically, affirmation and negation are two entirely opposite concepts that are universal in all human languages. Researchers found that negative sentences are more difficult to process than affirmative sentences in general (Wason, 1961). Besides, it is also more difficult to process the real negative sentences that correspond to the actual situation (Arroyo, 1982). In Mandarin Chinese, negation can be divided into different types by different standards. For example, negation is generally classified into semantic negation and pragmatic negation in terms of its property in which the former consists of propositional, conceptual, truth-value and logical negation while the latter is comprised of implicit, presupposed, metalingual and redundant negation (Zhang, 2015). As such, it is negation that exists in languages in its various forms and serves for distinct functions.

Previous research suggests that the processing of negative sentences can be influenced by their intrinsic properties owing to the multiplicity of the negative sentences. Therefore, their online

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processing mechanism would be different when being comprehended by the addressee. According to Mayo et al. (2004), the processing of negation depends on the types of negation. In consideration of the complexity of the negative sentence patterns, researchers found that there are incongruent views about them which results in various theories of the processing of negation.

In general, the negation can be divided into contradictory negation and non-contradictory negation. Besides, these two kinds of negation correspond to such negative sentences as the literal negative sentences and metaphorical negative sentences. They were utilized to investigate whether the processing would change or not when the properties of negation have changed (Li et al., 2017). The literal negative sentences mean that the specific negation can be easily extracted from the surface of those sentences (e.g. the door is not closed.) while the metaphorical negative sentences cannot be comprehended without reaching to the deep sense (e.g. the boy is not a devil.). It is obvious that the former refers to a statement about the state of the boy while the latter constructs a relationship between the boy and the devil, namely, the addressee needs to retrieve information or properties of the devil at first in the course of comprehension. In fact, there were differences between the literal negative sentences and metaphorical negative sentences and both showed different mental representations in the late processing of the negative sentences. Altogether, the inhibition of the negated information performs diversely in different types of negative sentences above. At the end of processing, the negated information in the literal negative sentences is inhibited with the actual state of affairs being presented. But in metaphorical negative sentences, the negated sense remains in the mental representation all the time instead. However, Du et al. (2014) held that the actual state of affairs was activated to be available directly in the contradictory negation. It was consistent with the result of the study by Mayo et al. (2004). According to Du et al. (2014), the negated state of affairs was not always represented unconditionally. Therefore, how the negated information is represented depends on the types of the negative sentences.

Apart from negative sentences differed by their inner sense, there is a very special negative sentence called the double negative sentence which expresses affirmative meaning although it is in the form of negation. Zhao et al. (2014) found that the double negative words were overall processed instead of by each part after the investigation of the early processing mechanism of double negative words. The actual state of affairs was all represented directly by such different sentence structures as negative rhetorical questions, affirmative imperative sentences and double negative imperative sentences. When the syntactic form was inconsistent with the semantics, addressees were more affected by the semantic properties of the sentence. It failed to prove that the double negative sentences were based on the two-step simulation. In view of the limitation of the behavioral experiments, the processing time of the negation is so short that it is hard to measure it precisely. Therefore, the neurocognitive methods with high temporal resolution could be used in future research.

3.2 Modulation of Context in Negative Sentence Processing

In fact, in order to avoid the influence of irrelevant variables, researchers tend to isolate experimental materials from the natural language context on purpose in the process of experimental design so as to ensure the reliability and validity of experiments. However, context is an important factor in natural language processing. Language research without context is incomplete for language comprehension is a complex cognitive process. In general, context consists of language context and non-language context. Research has shown that language context has a restrictive and coordinated effect on sentence comprehension (Zeng & Liu, 2009), which contributes to promoting semantic processing and integration of information in sentences.

Therefore, the introduction of context into language research has become a new perspective to investigate the processing of negative sentences. In fact, language processing usually takes place in an active and incremental way rather than getting a complete proposition passively with its meaning being fully expressed by the speakers and accepted by the readers respectively (Altmann & Mirković, 2009; Pickering & Garrod, 2007; Pritchett, 1991). There is sufficient evidence to show that negative sentences may be exceptions to the information increment pattern and they are integrated instantaneously without a full explanation. Recently, many facts indicate that the difficulty in information increment processing related to negation is actually limited to some specific situations while the lack of contextual information is the main reason for the irrational and inefficient use of negation.

On the other hand, the abundant language contexts imply a certain kind of predictability and narrow the range of possible communicative meanings to make it possible to predict the content of negative

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sentences more accurately (Dale & Duran, 2011; Nieuwland & Kuperberg, 2008). In the strong context and the weak context, eye movement technology is always adopted to explore a classic topic, i.e., whether the essence of negation processing is the propositional representation or experiential simulation (Chen et al. 2018). The results show that both are involved in the negation process, which supports the mutual integration of the two theories. In other words, the overlapping effect of propositional representation and experiential simulation exists in the processing of negation.

The anchor-based activation and satisfaction-constrained model proposed by Chen et al. (2014a, 2014b) can be used to reveal the processing mechanism of negative sentences with uncertain states. According to Chen et al. (2014a, 2014b), the anchor which refers to the negated state of affairs is firstly activated before expanding and searching around it. When a certain state of affairs can be obtained by means of linguistic property or context, it is regarded as the final state. Otherwise, the available clues will be used up with the stoppage of information searching. At this moment, the state of affairs with a negative tag can be regarded as the final state at the end of the processing of negation. From the analysis above, the processing of negation is a dynamic process in essence, which can be influenced by the context.

3.3 Emotion and Negative Sentence Processing

There is an interaction between negation and emotion (Gao et al., 2019). The representation of emotion is a special form in the processing of negative sentences. Negation is a common linguistic phenomenon that denotes the antithesis of the negated state of affairs. There is no doubt that emotion being existent in negative expression conveys some kind of preference. Negative emotion in language can be conveyed by such negative words as "*bu*", "*meiyou*", "*wei*" and so on. The redundant negation, as the most typical form of negation in Mandarin Chinese, is mixed with the speaker's emotional property to some great extent. For instance, there is a group of controversial redundant negative phrases that imply the non-occurrence of the action, like "*chadianer*" and "*chadianermei*". In fact, both share the same meaning although the negative mark "*mei*" is added to the latter. In view of the linguistic phenomenon above, Zhu (1997) generalized two practical rules for this in *Research on Modern Chinese Grammar*: If it is something that the speaker expects to happen, the former indicates the negative meaning while the latter indicates the affirmative meaning; otherwise, both two phrases are used to express negative meaning. It further indicates that negative sentences are closely related to psychological emotion.

In addition, negative sentences affect the individual's processing of the affective meaning of the sentences (Jiang et al. 2014). In order to fully demonstrate the processing mechanism of emotional words in both different sentences, Jiang et al. (2018) employed a fNIRS (functional near-infrared spectroscopy) experiment to study again the same research questions mentioned above. The results showed there were some processing differences of emotional words at the end of the negative sentences and the affirmative sentences. However, the emotional valence of the final words was restricted by the negative sentence pattern, thus there was no significant distinction between positive and negative words.

3.4 Individual Differences in Negative Sentence Processing

The individual differences are generally ignored in the research on the processing of negation. In the experiment, healthy adults are often regarded as the objects to carry out the study. Thus, there is very little literature on individual difference analysis in the field. Feng et al. (2020) used fMRI to explore the negative effect of a typical Chinese syntactic aphasia patient. For the aphasia patient, more brain areas were involved during the processing of the negation and the corresponding compensatory mechanism was activated. In other words, it indicated that brain damage affected language comprehension to a great extent but other districts of the brain would share the function.

Moreover, age as one of the individual differences is a non-negligible factor that might influence the processing of negative sentences. In the early stage of language development, children would compare affirmative sentences with negative sentences at the same time in order to understand the actual function of the latter for the negative word is a special functional word (Reuter et al. 2018). The essence of the acquisition of function words is actually to acquire some combinatorial rules. Children would encounter a bottleneck in semantic processing of negation when they were young especially while switching between affirmative and negative tests might increase the burden of semantic processing independent of pragmatic influences. For example, during the acquisition of the negative

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form of the English language, children would firstly attach the negative element to the beginning or the end of the sentence. Next, the negative marks that are not inflected would be inserted into the sentence. In the final, they could produce appropriate negative sentence forms through inflection. For children, the comprehension of the negation is always based on the affirmative state of the sentences with more cognitive resources being consumed. However, age is not used as a variable to modulate the processing of negation by researchers.

Besides, other individual differences should also be given more attention, such as working memory, the types of aphasia patients, language backgrounds of subjects and so on. In short, how the processing of negation is affected by those individual differences remains unclarified at present.

4. Future Direction of the Research

The research on the processing of negation has yielded many results, but there are still problems to be solved. How to reveal the cognitive mechanism of the negation has been a hot-spot issue. In order to further promote the development of this field, future research will focus on the following aspects:

First, the research objects should be further expanded. There is always a lack of such longitudinal studies that cover from children to old people for only healthy adults were generally recruited in light of the extant research. In other words, subjects of age groups could be selected to study in the experiments. Besides, the aphasia patients or those people with loss of language ability are also available. Thus, diversifying the experimental subjects is helpful to make a comprehensive analysis of the processing mechanism of negation and the research on the language development of humans.

Second, extend from native speakers to Chinese as a second language learners with different language backgrounds. In fact, subjects in the previous studies of Chinese negative sentence processing were limited in native speakers. As there is hardly any research on L2 learners, the second language research of the negative processing should be carried out so as to contribute to the development of second language acquisition.

Third, utilize new research paradigms and integrate multiple experimental technologies. As for the processing of negation, previous studies were mainly based on the word-picture judgment paradigm. Meanwhile, such neurocognitive technologies as ERPs, fMRI and PET have their limitations. Therefore, in future research, multimodal fusion or the integration of the technologies is a new trend to fully improve the reliability and validity of the experimental results.

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