Working Memory and Language Processing

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Abstract: Language processing is an important part of psycholinguistic research which mainly focus on the factors affecting the processing process.Among them, working memory is one of the important factors affecting the process of sentence processing. Starting from the concept and characteristics of working memory, this article elaborates the relevant theories of working memory and the influence of individual differences in working memory breadth on sentence processing, and finally puts forward the prospect of future research.

Keywords: Working;Memory; Language processing

Sentence processing is a highly complex cognitive activity in which the brain processes and understands sentence information. In recent decades, studying the process of sentence processing has become an important area in psycholinguistics. Research show that sentence processing is influenced by syntax, vocabulary, discourse, context, prosody and working memory.

1. Definition of working memory

Working memory is a cognitive system that allows us to keep limited information alive in a short period of time (about a few seconds), while the amount of information that humans can process is about 7+2 blocks (Miller1956). In the 1950s, working memory was once known as short-term memory. At that time, the academic circles believed that long-term memory stored declarative knowledge, such as vocabulary and procedural knowledge, such as output, while short-term memory was mainly used to store information, which can be converted into long-term memory (Atkinson & Shiffrin 1968). But later studies have found that short-term memory also has a buffer function (Baddeley1986)[2].Strictly speaking, this buffer zone is the working memory. Working memory refers to the process or cognitive system that temporarily stores, operates and extracts the information from the outside world. Therefore, working memory emphasizes both storage and processing;

2. The role and characteristics of working memory

2.1 Role of working memory

The concept of working memory was proposed by Baddeley and Hitch (1974), Baddeley et al. believe that working memory has both functions of storage and processing, which is different from short-term memory that only emphasizes storage function. In the process of language understanding, the processing function is the recognition of vocabulary, meaning and syntax in language materials and the understanding of sentence meaning; The storage function is storing various intermediate representations produced in the processing process and providing necessary output materials for processing links at different levels[4].

2.2 Characteristics of working memory

The biggest characteristic of working memory is that it is a limited resource, and the storage and processing will compete for resources. When cognitive activity is new or more difficult, more processing capacity is needed, which reduces the space needed for storage functions. Another characteristic of working memory is reflected in the difference of working memory ability of different individuals. Individual working memory capacity can be assessed using working memory breadth or working memory capacity. Over the last decade, A large number of studies have shown that cognitive activities such as problem solving, reasoning, and reading comprehension can be influenced by individual differences in working memory capacity. For example, Just and Carpenter (1992) believe that readers with small working memory capacity use more resources for information storage when reading comprehension sentences, and relatively few resources for processing, so their reading efficiency is low[1].

3. Theory of language processing

In complex tasks such as understanding, learning, and reasoning, working memory can store information, keep it active, and manipulate it. So, what is the relationship between sentence processing and working memory?

Most of the sentence processing circles believe that sentence complexity is subject to working memory. There are three views on the relationship between language processing and working memory. The first is the "Separate Verbal Resource Theory" represented by cognitive neuroscience researcher Caplan & Waters (1999). The theory divides verbal working memory into two parts.One is for interpretive processing of language, That is specifically used for sentence comprehension.The other one is used for non-verbal.But it is a cognitive task that requires language as a mediator.These two blocks of verbal memory resources are independent and highly specialized (Caplan & Waters 1995,1999)[3].

The second view is the "Single Verbal Resource Theory", represented by Just & Carpenter (1992). The theory holds that both processing language and completing non-verbal cognitive tasks depend on a common verbal working memory resource.It believes that language, like other cognitive activities, has no special features and advocates non-specialization of language processing (Just & Carpenter 1992; MacDonald et al.1992; King & Just1991). The theory is rooted in interaction effects in various cognitive processing processes. Both declarative and procedural knowledge are stored in long-term memory, while short-term memory or working memory exist independently, storing some of the current input and the intermediate steps of operation, allowing information from different channels to be used in parallel.

The third view, represented by MacDonald, holds that our language processing capacity emerges from brain network mechanisms and language experience, and is not an element that can change independently. The individual differences in sentence comprehension need not be attributed to the size of the "independent working memory" capacity, because the working memory effect is only a derivative of the accumulation of language experience, which is only redundant. But that view is not the mainstream.

4. Individual differences and language processing

Since the 1990s, many sentence processing scholars of psychology have begun to realize that different personal cognition may also affect the way that people organize and process language information. Individual differences have gradually become a part of the research content of language processing.

The assertion that personal cognition is related to language processing is mainly based on the study of working memory. Researchers explain why some sentences are difficult to process by memory. Participants can be grouped by memory capacity through standardized tests, such as the reading breadth test. If a sentence is difficult to understand because it is beyond memory capacity.It can be predicted that subjects in the low memory span group are more likely to collapse when understanding such sentences, while those in the high memory span group will perform differently.

The results of the English relationship clause processing all show that the object clause is more difficult to understand than the subject clause, which implies that the object clause requires more memory. Just & Carpenter (1992) divided participants into high and low memory span according to their performance on the reading span test. It was found that for the English subjects with low memory span, reading the object clause is indeed slower than the subject clause; but for the high memory span subjects, processing the object clause is only slightly difficult, indicating that their cognitive resource capacity can accommodate the structure.

However, there may be another situation in which the low breadth subjects processed the disambiguation differently from the high breadth subjects. Many factors can affect the disambiguation. Just & Carpenter (1992) believes that in the process of ambiguity resolution, high memory breadth participants are better at using different information at the same time, while low memory breadth participants can only take into account the limited amount of information.

But not all researchers agree with Just & Carpenter (1992) that object clauses are difficult to process because working memory resources are too demanding. For example, represented by MacDonald, scholars based on the empirical theory are proposed that the processing of object clauses is difficult because of its low frequency of occurrence and less opportunities of daily contact. Therefore, the familiarity of the sentence pattern is lower and more difficult to understand. Researchers in the empirical theory camp refuted the correlation between memory breadth and processing difficulty. They questioned whether the reading breadth test could be used as a credible means to measure memory ability. MacDonald & Christiansen (2002) believes that some people do well on memory tests, not because they have greater memory capacity, but because they are better at reading. MacDonald & Christiansen (2002) suggested that participants' high scores on the reading span test showed only that they could understand the

sentence without any effort, rather than that their high memory capacity. Therefore, this test only reflects the amount of reading training that the subject has accumulated over the years. As for why experienced readers can understand unusual structures like object clauses, MacDonald and colleagues believe it is likely because they often see these sentences in everyday reading, especially more likely to be written. This view is true, at least in English, where complex long sentences or nested sentence patterns are often more common in formal, solemn written languages.

To sum up, the debate about individual differences and working memory ultimately boils to two crucial questions:①To what extent does the reading span test reflect memory capacity? Are other potentially more "pure" memory tests also positively correlated with the difficulty of complex syntactic processing?②To what extent does language experience affect both memory tests and language processing tests? In this academic debate about the difficulty of memory and processing, individual differences have changed from statistical "noise" to a highly influential factor, which has some implications for the nature of human sentence processing.

5. Future prospects

First of all, the interdisciplinary nature of sentence processing research will become more and more prominent, and it will continue to cross and integrate with cognitive science, neuroscience and computer science.Secondly, brain imaging research in cognitive neuroscience will be the focus of future research. As cognitive neuroscience advances in high-precision instrumentation and data analysis, functional MRI and brain imaging technologies will continue to provide important fresh data for sentence processing research. Thirdly, the research of sentence processing will pay more attention to investigate how semantics is combined with syntax, and jointly affect the real-time understanding of sentences and texts. Finally, more cross-language research will emerge in the field of language processing research. Language processing has been dominated by English, a single language for a long time, but each language has its own specificity. Only after examining as many languages as possible can the applicability, accuracy and predictability of the theory or model be tested.

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