



# Brain Evoked Potential Analysis of Second Language Acquisition from the Perspective of Neurolinguistics

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## ABSTRACT

The current researches on the foreign language vocabulary attrition mainly focuses on the nature, time and order of the attrition of foreign language vocabulary, but there are few experimental researches using new technological means. In this paper, students who are native Chinese speakers are taken as the subjects to conduct two behavioral experiments and event-related potential (ERP) experiments. The results show that subjects have the attrition of foreign language vocabulary. N1 and N400 effect are found in the results of the two experiments, in which both concrete nouns and abstract nouns show the weakening of N1 component and enhancing of the N400 component. In the trend of brain evoked potential, the amplitude of N1 becomes smaller while the amplitude of N400 becomes larger. These results indicate that foreign language vocabulary leave traces in the brain when it is extracted again, and English nouns appears attrition. As the most common word class in English, the attrition time of Chinese learners to this word class is short and the attrition even occurs within three months.

**Key Words:** Attrition of Foreign Language Vocabulary, Vocabulary Training, Concrete / Abstract Nouns, ERPs, N1, N400

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## Introduction

Human beings are born with the ability to acquire their native language. However, it is still a hang-up how human beings learn foreign languages and how their foreign language ability declines (Kissler *et al.*, 2015). Of all ages, as long as different languages live adjacently, people will inevitably try to communicate out of the boundary of language. It is the most common and meaningful method to learn each other's language. However, it is easy to learn a language, especially a foreign language. Nobody can state clearly what the principle of foreign language learning is. Although we feel that the process of mastering our mother tongue is so simple, foreign language learning is often troublesome for many

foreign language learners (Schurz *et al.*, 2015). By its nature, the difficulty of language learning lies not only in the process of language acquisition, but also in how to maintain the obtained language ability to delay or avoid its attrition.

Language attrition refers to the decrease or stop of use frequency of one or more specific languages held by bilingual or multilingual speakers due to physical, psychological, cognitive, and social factors so that non-pathological, intra-generational, repeatable, and individual decline of a specific or several language abilities occurs over time (Klein *et al.*, 2015).

In the study of contemporary linguistics, compared with the study of language acquisition, the history of language attrition is short with less

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than thirty years from the first language attrition academic conference to its establishment of a relatively independent study in the 1980s. However, the research in this field has already achieved more abundant results (Besnard *et al.*, 2016). In the study of language attrition, foreign language attrition has attracted the attention of researchers from various countries for its wide range of research objects, large application value of research results, and the abundance of attrition components. The study of foreign language vocabulary plays a very important role in foreign language learning. Therefore, foreign language attrition, especially the attrition of foreign language vocabulary, is a problem that foreign language learners have to face (Wilkinson *et al.*, 2015).

At present, the relationship between foreign language vocabulary attrition and foreign language acquisition and memory forgetting is still lacking evidence from neuroscience research. A more concrete and intuitive empirical research will help to clarify the relationship between foreign language vocabulary attrition and learning and memory, which will be of great significance for studying language processing and language learning (Bocanegra *et al.*, 2015). To sum up, combined with the actual situation of foreign language learners in China, this paper will adopt neuroscience research to study the nature, time and order of English learners' vocabulary attrition in the Chinese language environment and the relationship between it and learning and memory.

In English vocabulary learning, nouns are a very important and common word class. The quality and quantity of mastered vocabulary of nouns is directly related to the final level of foreign language learning. In the study of foreign language vocabulary attrition, comparative studies of the attrition within nouns, such as the attrition process of concrete nouns and abstract nouns, have no conclusion yet (Langer *et al.*, 2015). From the study of brain lexicon, nouns, as the most stable and independent word class, have a concrete and abstract significant separation in semantics. This separation phenomenon will help to investigate the potential cognitive neural mechanism of foreign language vocabulary attrition (Ivanova *et al.*, 2016). Therefore, the concrete and abstract nouns in the English vocabulary of native Chinese speakers are taken as the basic corpus for studying foreign language vocabulary attrition. Subjects are given English nouns vocabulary training. Through learning and

training, the entire stage from acquisition to attrition of English nouns by the subjects can not only be consistent, but also many factors, such as the time of subjects' acquisition of English and meaning of English nouns can be effectively controlled (Houde *et al.*, 2015).

The purpose of this paper is to use the research method of neurolinguistics to explore the nature, the attrition time and order of English nouns in native Chinese speakers. Then this paper focuses on the behavioral indicator and electrophysiological indicator (ie, ERP indicator) of the processing of English concrete nouns and abstract nouns before and after the attrition so as to further explore the issues related to the foreign language vocabulary attrition and its relationship with other cognitive abilities.

## **Experimental research on the attrition of English nouns by native Chinese speakers**

### ***Early-stage preparation***

In this experiment, a total of 20 university students (ratio of boy and girl is 1:1) who are native Chinese speakers of non-English major with English as a foreign language are taken as the subjects. Their ages range from 18 to 25 years old. Their vision is normal or normal after correction and they are all right-handed without brain trauma or other mental illness. The students' English proficiency is CET-4, and the subjects do not learn a third foreign language other than English. In order to ensure the consistency of the starting point of learning and the learning effect, the experimental corpus of this paper are English nouns that subjects have never seen or are not familiar with. There are a total of 100 concrete and abstract English nouns. In the subsequent behavioral experiment and ERP experiment, a total of 120 English nouns (a half of concrete nouns and a half of abstract nouns) are used as experimental corpora for taking into account the time of the experiment and the length of the paper (Klaas *et al.*, 2015).

### ***Experiment contents***

According to the purpose of the experiment, the experiment contents include three parts: vocabulary training, behavioral experiment and ERP experiment, among which the behavioral experiment and the ERP experiment are performed twice respectively, and the interval is two months.

### Vocabulary training

The purpose of this vocabulary training is to expect subjects to learn English nouns that are previously screened in the short term. The training program is an intensive training for 7-10 days for subjects. Five-person group is set and they are trained for one hour a day. The training contents include four items: listening, speaking, reading and writing. The entire learning process of vocabulary knowledge can be divided into five stages:

**Table 1.** Vocabulary knowledge scale

Learning stage	Rate of learning
Stage 1	I don't know the word.
Stage 2	This word has been seen, but it doesn't mean what it means.
Stage 3	I know the word, and I can probably know what it means.
Stage 4	I know the meaning of the word.
Stage 5	I know how to use this word.

### Behavioral experiment

The behavioral experiment in this paper adopts background questionnaire survey and written task. The background questionnaire survey is conducted on the subjects before the vocabulary training to understand the basic situation and the status of the English learning of the subjects, which is also a basis for screening the subjects. At present, the written task is the most common way to study the attrition of adult language, generally in the form of Test. This English nouns test consists of four parts and each part has 30 questions. The first part asks the subjects to use the given nouns to make sentences based on the given sentences, and to maintain the consistency of sentences; the second part requires the subjects to write the English paraphrasing of the following concrete nouns or abstract nouns; the third part is to use the given nouns to fill in the blanks to make the meaning of the sentences complete; the fourth part is to connect the given English nouns with their English interpretation.

### ERP experiment

The experiment is conducted for twice and the time is the same as that of behavioral experiment. The purpose of the experiment is based on the induction of ERPs and changes in behavioral indicators. In addition to the 120 nouns, the experimental corpus also selects 60 additional words and a corresponding number of related and unrelated words. The experiment is divided into 3 Blocks, each Block has 20 concrete nouns and 20

abstract nouns, 20 filler words and corresponding semantic related or unrelated words with a total of 360 stimuli. Among them, the selection of related and unrelated English nouns is based on Nation's English general vocabulary and Chinese English textbook vocabulary of junior or senior high school.

## Results and discussion

### Behavioral experiment results

Through the statistics on the scores of the two behavioral test papers, the average accuracy of the concrete nouns and abstract nouns in the two experiments is analyzed as shown in Table 2:

**Table 2.** Statistical table of behavioral experiment

Statistical project	Behavioural experiment 1 (Average Accuracy %)	Behavioural experiment 2 (Average accuracy %)
Examination paper	96.61	56.55
Specific English nouns	97.01	63.24
English abstract nouns	96.22	49.87

Table 2 shows that the subjects achieve a very high accuracy both in concrete nouns and abstract nouns in the behavioral experiment 1, indicating that subjects have well mastered these extremely low-frequency vocabularies. In the behavioral experiment 2, the accuracy of the subjects in both types of nouns decreases significantly. From the structure of the test paper, it can be seen that the accuracy of the subjects in the acceptance and productivity tests also declines, which is a manifestation of the decline in English vocabulary ability, indicating that English nouns in this experiment have attrition.

### ERP experimental results and statistical analysis

#### (1) Behavioral data and statistical analysis

Through statistical analysis, the average accuracy and average reaction time of concrete nouns and abstract nouns under the two ERP experimental conditions are shown in Table 3 and Table 4:

**Table 3.** Statistics table of ERP experiment 1

Statistical project	Average correct Rate (%)	Mean reaction time (MS)
Specific English nouns	99.56	739.59
English abstract nouns	98.74	771.82

Table 3 shows that the accuracy of judgment of the subjects is very high, indicating that the subjects complete the experiment seriously and



the subjects well master the target words. From the reaction time, the reaction of abstract nouns is slightly longer than that of concrete nouns, which is basically consistent with previous studies. In view of the purpose of this paper, a one-way analysis of variance for reaction time data for concrete nouns and abstract nouns is conducted. The results show that the difference of concrete nouns and abstract nouns is not significant in reaction time,  $F=10.847$ ,  $P=0.440$  ( $P<0.05$ , it reaches significant difference).

**Table 4.** Statistics table of ERP experiment 2

Statistical project	Average correct Rate (%)	Mean reaction time (MS)
Specific English nouns	66.57	1235.81
English abstract nouns	51.36	1567.49

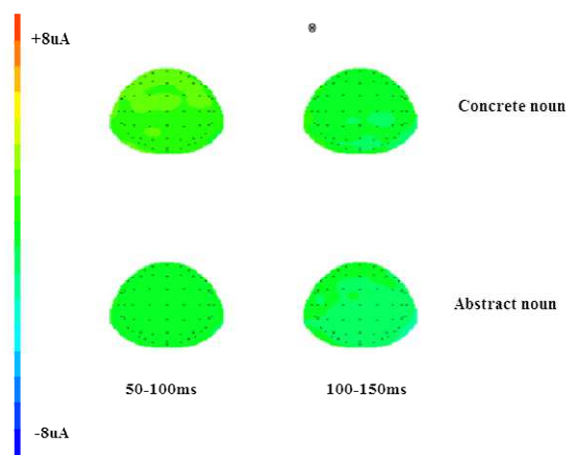
Table 4 shows that after two months of attrition, the accuracy of the two types of nouns is lower than 80%, indicating that the subjects' vocabulary ability decreases in both types of words and the accuracy of concrete nouns is higher than that of abstract nouns. In terms of reaction time, the reaction time exceeds 1000ms, and the reaction time of the concrete nouns is shorter than that of the abstract nouns. The result of one-way analysis of variance in reaction time shows that the difference in reaction time of the two types of words is significant,  $F=17.361$ ,  $P<0.001$ .

From the behavioral data of experiment 1 and experiment 2, the average accuracy of concrete nouns is always higher than that of abstract nouns, and the average reaction time is shorter than that of abstract nouns; however, in ERP experiment 2, both average accuracy and reaction time of concrete nouns and abstract nouns decline, indicating that after two months, concrete English terms and abstract nouns have gone through attrition, and the attrition degree of concrete nouns is lower than that of abstract nouns.

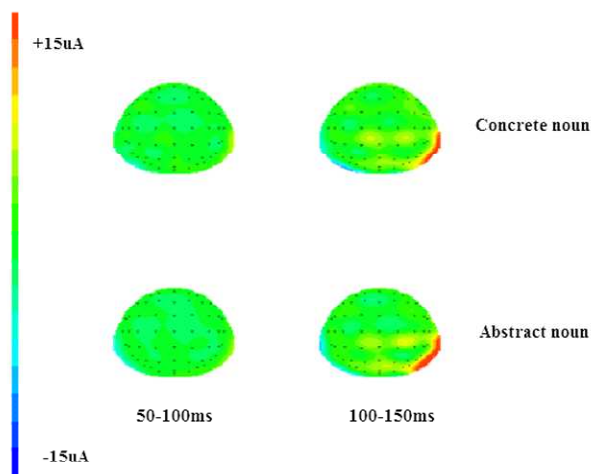
**(2) ERPs data and statistical analysis**

The average wave amplitude difference of oscillogram in the 50-150ms time window is analyzed. The specific results are shown in figure 1 and 2. From which, it can be known that after two months of attrition cycles, the new English nouns learned by the subjects before, namely the concrete nouns and the abstract nouns not only appear in the waveform but also abstract nouns deduce more obvious N400 component than specific nouns, that is, anti-specific N400 effect appears. In addition, the one-way analysis of

variance in the difference in the anti-specificity of the N400 reveals that the mean difference value between the two types of nouns in the left hemisphere, midline, and right hemisphere is  $-0.826$ ,  $-1.271$ , and  $-0.914$ , of which the mean difference value is the largest in the midline. The results of one-way analysis of variance indicates that the difference between the left hemisphere and the right hemisphere is not significant,  $P=0.074$ . Therefore, the anti-specific effect is the largest in the midline.



**Figure 1.** Comparison of topographic map of English concrete and abstract nouns in 50-150ms in experiment 1



**Figure 2.** Comparison of topographic map of English concrete and abstract nouns in 50-150ms in experiment 2

**Conclusion and outlook**

This research adopts ERP technology combined with behavioral experiment that is conducted for twice to examine the attrition of concrete nouns and abstract nouns of native Chinese speakers. The experimental results show that the reason why English abstract nouns can deduce larger N400 is that they have more attrition, which



makes it difficult to extract semantics. This shows that the processing nature of foreign language vocabulary attrition is likely to be difficult to extract, and may leave traces in the brain when it is extracted again.

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