The Connectionist Approach of Processing

L2 Ambiguous English Sentences

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Abstract

The connectionist approach to language processing is popular in second language (L2) study in recent years. The paper is to investigate the connectionist approach of Chinese learners' individual differences in the comprehension of certain ambiguous English sentences. Comprehension accuracy and grammaticality judgment are carried out with three groups with different background of language experience, namely, well-experienced English natives (group 1), well-experienced non-native English learners (group 2) and semi-experienced non-native English learners (group 3) on four types of ambiguous English sentences such as *The polite actor thanked the old man who carried the black umbrella*. Results of the study are discussed and a number of conclusions based on the results are summarized with regard to L2 learners' differences in the performance to comprehend ambiguous syntactic structures.

Keywords: Connectionist approach, Syntactic knowledge, L2 ambiguous sentence processing

1. Introduction

Many researchers are interested in L2 sentence processing, as there are debatable issues such as the nature of L2 differences in sentence processing (Bock, 1986; Seidenberg & MacDonald, 1999). Among which, connectionist approach to sentence processing seems to get increasing support in recent studies (Hopp, Mayra & Arriaga, 2016). To begin with the understanding of connectionist approach, it is useful to start with the architecture of connectionist approach. Connectionist approach is based on connectionist networks consisting of a number of simple but highly interconnected processing units called nodes or elementary units (Rumelhart & McClelland, 1986; Cuetos, Mitchell & Corley, 1996; Loebell & Bock, 2003). The whole network is a dynamic system connected by nodes with different weights. The dynamic system operates in this way: when a unit is activated by another unit, the unit calculates the output signals through a process of weighting the input signal, summing the weighted input signals, and then transmits the result to one another weighted connections (Mitchell, Cuetos, Corley & Brysbaert, 1995).

Since the connectionist approach is a network association with different weight of nodes, for language learning to take place, a pattern of inputs is taken into the input layer. Signals generated in the input layer are then propagated through the hidden layer to the output layer. The output value of each output unit is then compared against the value which that unit is supposed to produce when training is complete. The difference between that actual output and the desired output is then taken to alter the connection weights between that output unit and the hidden connected units. The difference is also applied to alter the connection weights between each hidden unit and the input units connected to it. The process is running repeatedly until a set of given weights is found that allows the input pattern to be transformed into the desired output pattern. An important consequence of this operation is that the knowledge of the network is not localized in one place, but instead is distributed across the network. The absence of a central executive to control processing is fundamental to the connectionist framework. For the connectionist learning, language performance or proficiency is, therefore, the accumulation process, among which, the proficiency is a piecemeal process in getting the proficiency. By this logic, it is reasonable that learners' differences in L2 sentence processing are related to experiences or the amount of exposure to L2 language.

The connectionist approach, however, is criticized by the rule-based approach which holds that individual differences in the performance of comprehending sentence are based on the phrase structure rules (Chen, 2006). According to

Chomsky's (1965) theory, human linguistic abilities are rule-governed:

Normal use of language involves the production and interpretation of sentences that are similar to sentences that have been heard before only in that they are generated by the rules of the same grammar (1966, 11).

By Chomsky, grammatical rules are recursive, it is possible to self-embed sentences infinitely. For example, a relative clause may be embedded one or several relative clauses and can continue endlessly, as in the sentence *The rat that the cat that the dog chased bit died*. According to Chomsky, this sentence can be added with other numbers of center-embeddings *The rat that the cat that the dog chased bit died* is no principle of English grammar that could sensibly limit the number of center-embeddings in the sentence (Hawkins, 1994). Therefore, understanding a sentence involves identifying its syntactic structure, as it is only on the basis of identifying the syntactic structure that the comprehension of a sentence can be made (Shin & Christianson 2012). Thus, it seems that learners' differences in processing L2 sentences are closely related to the skill of syntactic knowledge.

It could be seen that the connectionist approach differs from the rule-based approach in the nature of L2 learners' differences in sentence processing. In order to clarify the differing views on the true nature of learners' differences in the performance of L2 sentences, it is necessary to investigate ambiguous sentence comprehension, since this comprehension process involves dealing with the syntactic knowledge, which is a good test stone for judging the above different views on L2 sentence processing mentioned above. In so doing, studies of grammaticality judgment and comprehension performance are conducted with Chinese learners of English on ambiguous L2 English sentence comprehension in the following section 2. Final conclusions (section 3) are drawn with regard to processing the four types of L2 ambiguous English sentences.

2. The Current Study of L2 Ambiguous English Sentence Comprehension

Aims: It is aimed to investigate the processing of four types of L2 English ambiguous sentences with Chinese learners from different language experience (see the subjects below), with the expectation to see the different performance in grammaticality judgment and comprehension outcome.

Subjects: Subjects are from different language experience consisting of three groups: well-experience non-native English speakers (group 1); well-experienced native English speakers (group 2); semi-experienced non-native English speakers (group 3). Group 1 is 20 non-native English speakers who are of French, Greek, Russian and Chinese origin. They all had a degree in a language-related subject and were taking post-graduate study in either Applied/Historical Linguistics (five people) or in Education Studies (three people) at the University of Sheffield. Four of the subjects were third year PhD candidates in Historical Linguistics. All of them had the experience of being exposed to the English speaking environment and had received formal training in English for more than one year in mainland China or in UK by the time of the experiment. Most (eight subjects) of them had been English teachers in their home countries, where they taught English using explicit grammatical rules.

Group 2 is 20 native English speakers who had a degree in language-related subjects as well. Seven of them were undertaking post-graduate study either in Applied/Historical Linguistics in English Literature; the other five were doing PhD research in Literature at the University of Sheffield. Some natives stated that they had learned grammar at school, but that grammar was restricted to spelling and punctuation.

Group 3 is 20 Chinese learners of L2 English who are near fluent English speakers. Their mother language is Chinese, and English is the L2. They have received less than 11 years' formal instruction in English. They are senior school students at Beijing No. 20 Middle School at the time of the experiment.

Materials: The material includes four types of English ambiguous sentences: *1) While the band played the song pleased all the customers* (type 1); *2) The polite actor thanked the old man who carried the black umbrella* (type 2); *3) We know where you are about the quality of your products* (type 3)*; 4) Anyhow, I am afraid the implications of these two terms are somewhat different* (type 4). The rational for using these structures is that they are ambiguous either in word meaning or sentence meaning or sentence grammatical structure. The first type is ambiguous due to the temporal syntactic ambiguity (i.e. *the band played*). The second type is ambiguous due to the syntactic ambiguity (i.e. *who carried the black umbrella*). The third ambiguous type results from the meaning of ambiguous clause (i.e. *where you are about*). The fourth type is ambiguous in that the sentence ambiguity is caused by word meaning (i.e. *terms*). Furthermore, these structures require the recursive application of grammatical rules. The material is made and revised based on Chipere's (2003) and Ren's (2013) testing structure.

Procedure and method: The comprehension test was conducted in a classroom for group 3, where subjects were asked to read the sentences and answer the questions to the sentences. Two weeks later, this group was asked to do grammaticality judgment in the same classroom. The grammaticality/

acceptability judgment of each sentence is judged by a scale of numbers from 1 (completely ungrammatical) to 5 (completely grammatical) with examples as illustration. For group 1 and 2, they were given both the printed comprehension material (and the questions) as well as grammaticality judgment of the English ambiguous sentences during the break at the conference of English School at the University of Sheffield, where they were told to do them as best as they could, as they were professionals and their responses to the testing material would be taken as important measure for syntactic proficiency.

Results and discussion: Mean comprehension scores of sentence structures are shown in table 1. The results show that well-experienced non-natives obtained the higher comprehension scores than that of the well-experienced natives in the comprehension of sentences in type 3 and 4; the semi-experienced Chinese learners of English obtained the lower comprehension than that of the well-experienced native speakers of English in the whole comprehension performance. The main effects of groups for the key questions was significant, The results can be explained in terms of effects of language experience on comprehension, whereby the explicit grammatical instruction was given to well-experienced non-natives, while learning English gave them an advantage over the native speakers; as the relatively more schooling or instruction with English makes it possible for the well-experienced non-native English learners perform better than that of the semi-experienced Chinese learners of L2 English.

Table 1. Mean Comprehension Scores of sentence structure (by percentage)

Structure	Group 1	Group 2	Group 3
type 1	0.512	0.613	0.312
type 2	0.723	0.752	0.134
type 3	0.531	0.514	0.221
type 4	0.812	0.781	0.215
Total mean score	0.645	0.665	0.221

Note: Group 1 = well-experienced non-native English learners
  Group 2 = well-experienced native English learners
  Group 3 = semi-experienced Chinese learners of L2 English

The effect of groups is generally compatible with the connectionist approach to L2 sentence processing, given that comprehension performance was found to be related to the level of language experience. This result gave less support to the common assumption that non-natives never reach native-like proficiency (see type 3 and 4), indicating that the more experienced non-native learners of English (of course with more exposure to English) have better performance in the comprehension than that of the less experienced learners.

Suppose that L2 sentence processing of non-natives may be subject to delays, inefficiencies or qualitative differences compared to native processing (Gibson & Pearlmutter, 1998), the experimental results show that the experienced and semi-experienced L2 learners did not show a reduced sensitivity to syntactic information in non-native parsing, at least from the sentence comprehension of the type 1 and type 2, which was against the shallow structure hypothesis (Felser & Roberts, 2007; Clahsen & Felser, 2007) that non-native parsing had a reduced sensitivity to syntactic information.

Table 2. Mean Scores of Grammaticality Judgment (by percentage)

Structure	Group 1	Group 2	Group 3
type 1	0.862	0.713	0.212
type 2	0.621	0.617	0.173
type 3	0.724	0.421	0.112
type 4	0.612	0.523	0.192
Total mean score	0.705	0.569	0.172

Mean scores of grammaticality judgment are shown in table 2. In the grammaticality judgment tasks, the rate of 'grammatical' judgments for type 3 and 4 is greater than the rate of correct responses to the key question for natives. For the semi-experienced Chinese learners of L2 English, on the other hand, the rate of 'grammatical' judgments is the same as the rate of correct responses for the key questions. The interaction between Groups and Questions (key question and grammaticality judgment is significant at $F_{(2,31)}=3.82$, $p<0.05$. However, the rate of 'grammatical' judgments is less than the rate of correct responses to the key question of the type 4 structures for all groups.
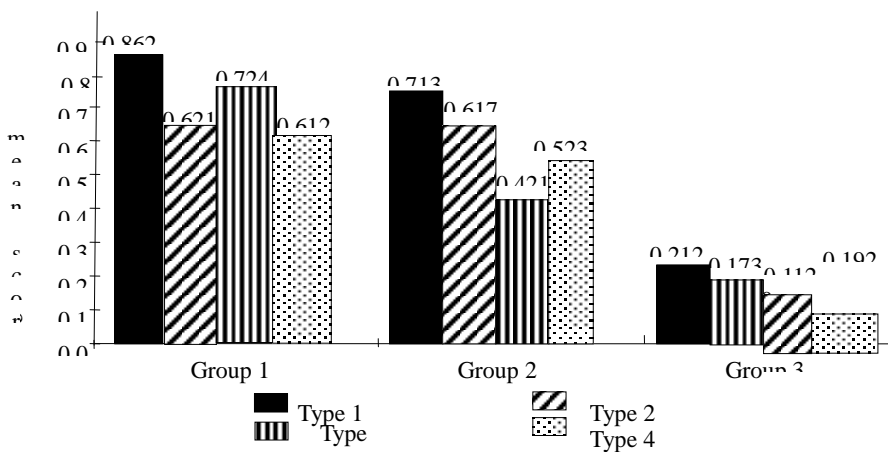
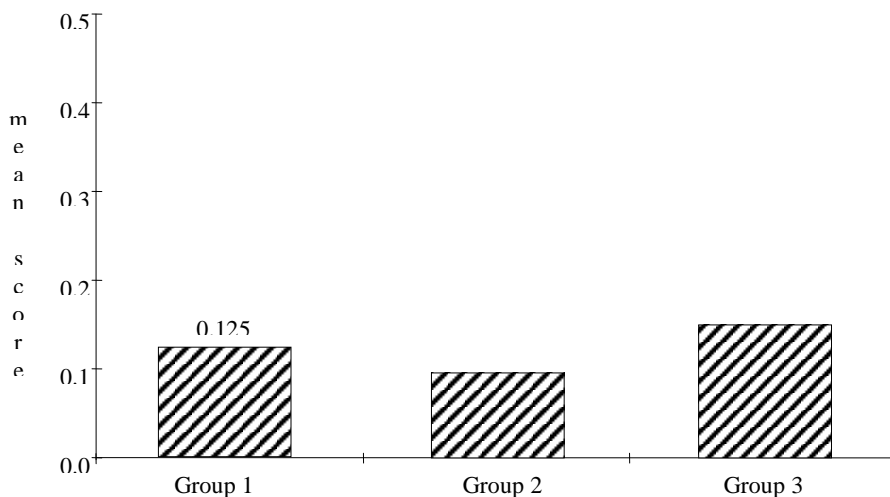Figure 1. Interaction of Groups x Grammaticality Judgment

Figure 2. Effect of Grammaticality on Comprehension

The effects of ambiguous structures suggest that subjects did not have a systematic knowledge of English grammar. It is interesting that this effect is greatest for the well-experienced non-native natives, followed by the Chinese learners of L2 English. The differences are related to group differences in explicit grammatical knowledge. Group 1, who had the most explicit knowledge of English grammar (on account of their linguistic background) perform in the most systematic way, followed by Group 3, whose explicit grammatical knowledge might be expected to be in the middle of the two groups. This pattern of group differences is consistent with the differences in automatic systematicity and non-automatic variety between experts and novices.

The explanation is supported by results from the task of grammaticality judgments (figure 1). The well-experienced L2 learners appeared to overrate their understanding of sentences of structure type 3, whereas Chinese learners of L2 English made grammaticality judgments which were consistent with comprehension responses (Juffs, 2006). This result suggests that the semi-experienced Chinese learners of English carried out both the comprehension and grammaticality judgment tasks in a rule-based manner (Luka & Barsalou, 2005). Their ability to perceive the syntactic structure of the test sentences also followed their grammaticality judgments.

Group 3 seemed to be most affected by Grammaticality (figure 2). The interaction between

Grammaticality and Groups is significant for the key question, $F(4,48) = 2.21$, $p<0.07$ and was significant when scores for both Questions 1 and 2 (the key question and the second most difficult question, respectively) $F(4,48) = 4.18$, $p<0.01$. There was no significant effect of Grammaticality for Group 1, $F(2,16) = 1.26$, $p<0.25$ or for Group 2, $F(2,16) = 1.42$, $p<0.23$, but the effect of Grammaticality on Group 3 was significant, $F(2,16) = 15.31$, $p<0.001$.

The structures used in the grammaticality judgment were all ambiguous English sentences but are different in degree of ambiguity. Given that language experience might contribute to L2 learners' differences in comprehending these ambiguous sentences (Pickering, & Branigan, 1999; Hernandez, Bates, & Avila, 1996), the amount of language experience with explicit rules of English grammar seemed to make little differences in the comprehension performance in terms of rule-based manner (Su, 2001; Lee, 2009). That is, the well-experienced non-native learners (group 1) who had relatively much more experience or instruction on English performed almost the same in grammaticality judgment as the semi-experienced learners who had less experience or instruction. It seems that there is a minimum amount of experience limitation for L2 learners to have the formal instructions on explicit English grammar rules, which is necessary for L2 learners' skill to comprehend the ambiguous English sentences.

3. Conclusions

The study investigated four types of L2 ambiguous English sentences from the perspective of the connectionist approach to sentence processing. Results show that reduced scores in grammaticality judgment relative to sentences with less experience with L2 English, and experience with syntactic structure in a sentence were instrumental in increasing comprehension accuracy. Since the study is employed ambiguous sentences, it should be cautious that the potential utility of experience-based meaning activation to reduce grammaticality scores and increase comprehension accuracy in L2 ambiguous sentence processing and thereby facilitate the automatic L2 comprehension skills.

Acknowledgments

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