Investigating Syntactic Ambiguity Resolution Strategy Use of
EFL Learners in Reading Relative Clauses

Yea-Ru Tsai
Applied English Department
I-Shou University, Taiwan

Abstract

This study investigates resolution strategies used by L2 (English) learners when they are reading syntactically ambiguous sentences containing relative clauses (RC). The participants of this study were 114 learners of English as a foreign language (EFL) in Taiwan. A questionnaire was constructed to gather information concerning the learners' processing strategies. Two grammatical aspects were considered: filler-gap dependency and local syntactic ambiguity between main verb (MV) vs. reduced RC interpretations. In addition, lexical information, such as noun animacy of RC heads, and noun phrase (NP) attachment to the higher or lower noun were also taken into account. Multiple one sample *t*-tests were conducted to investigate the students' performance under various conditions. The results show that there was no significant difference of distribution between strategy use of syntactic and non-syntactic information, indicating that the access to both kinds of information was parallel and interactive. The results are discussed with regard to Shallow Structure Hypothesis in L2 learners (Clahsen & Felser, 2006). The implications of L2 parsing research for the field of SLA are also presented.

Keywords: syntactic ambiguity resolution, resolution strategy, English relative clauses, L2 sentence reading

Introduction

Syntactic ambiguity resolution is one of the main problems in reading comprehension. During the last decades, there have been numerous studies investigating how people understand ambiguous sentences (MacDonald, Pearlmutter, & Seidenberg, 1994). Syntactic ambiguities are relevant to both theoretical linguistics and studies in language acquisition in that they involve complex linguistic properties that allow researchers to explore the mechanism of processing abstract knowledge of a computational system.

Current debates concerning ambiguity resolution in sentence reading comprehension often focus on the issue whether the processing of comprehension is principle-first (garden-path or syntax-based) and constraint-based (Vosse & Kempen, 2009). The principle-based models (e.g. Frazier, 1987) postulate that only the syntactic properties of the new input word are being analyzed during a first stage of processing an ambiguous input string. In contrast, constraint-based models (e.g. MacDonald, 1994) posit that the processing of syntactic and conceptual information is interactive and parallel. When encountering an ambiguous input string, multiple analyses are activated primarily and a competition of relevant constraints of any source is set up, such as pragmatic, discourse, semantic, morphological or syntactic information.

The second issue is concerned with the strategies used in resolving syntactic ambiguities in first language (L1) and second language (L2). There are various assumptions about whether and to what extent L2 processing might be different from L1 processing. First, it is possible that learners will transfer their L1 strategies to L2 (Rah & Adone, 2010), if the structures of L1 and L2 are considerably alike. Second, L2 learners might employ similar strategies to resolve syntactic ambiguities as native speakers. Third, it is possible that the processing mechanism of L2 is essentially different from that of L1. L2 learners might rely more on lexical and semantic information than native speakers as a result of limited structural knowledge (Clahsen & Felser, 2006).

Previous research on L2 ambiguity resolution has yielded heterogeneous conclusions to the issues addressed. Moreover, many studies have focus mainly on investigating highly proficient learners (e.g. Rah & Adone, 2010). Hence, the investigation of the subjects of the present study, intermediate Chinese-speaking EFL learners, can provide interesting insights into L2 processing mechanisms for a comparison.

The arrangement of this paper is as follows. Section two describes the relevant theories and strategies of syntactic ambiguity resolution. Research methods are presented in the third section. The fourth section presents the results. Finally, section five and six provide discussion and conclusion of the study.

Literature review

Theories of syntactic ambiguity resolution

Current research on syntactic ambiguity resolution can roughly be divided into two major categories which make distinct claims about the understanding of syntactic ambiguity. The first class of theories are principle-based models, also known as modular models, two-stage models or autonomous syntax models. The most representative model within this modular view is Frazier's (1987) Garden-Path Theory. The principle-based models claim that at the initial stage of sentence parsing, syntactic knowledge is the only source of information that are used for readers to interpret the meaning of the sentence. Other non-syntactic information is not available until a later stage of processing. Garden path effect is evoked by different interpretations of an ambiguous sentence. The parsing decisions are made at a time under the guidance of some universal syntactic principles, such as minimal attachment and late closure (Binder, Duffy, & Keith, 2001; Rah & Adone, 2010). Frazier and Clifton (1996) have later proposed a new theory called the Construal Theory. According to the Construal Theory, the resolution of syntactic ambiguity is based on information of two different types: primary and non-primary relations. Primary relations include the subject, predicate, verb complements and obligatory constituents of primary relations, whereas non-primary relations are associated in the currently active theta domain which is able to contain more than one possible attachment site (Van Gompel, & Pickering, 2000). The parsing decisions therefore involve a number of factors, such as the thematic processing domain, interpretative principles and language-specific rules.

The second category of theories is the constraint-based models (MacDonald, 1994; Snedeker & Truewell, 2004). These models claim that the parse does not only rely on structural principles but also non-syntactic information will be accessed. The different sources of information provide constraints to different degree. No particular principles determine a preferred interpretation at a time. Once the word string in the sentence is given, both syntactic and non-syntactic information (e.g., lexical, semantic, pragmatic and frequency) are simultaneously activated in parallel at each point in time (Lai, 2009). The representative of a constraint-based model is the Interactive Activation Model proposed by MacDonald, Pearlmutter & Seidenberg (1994). The constraint-based theories assume that processing difficulty can be attributed to a competition between the syntactic analyses that employs all sources of information in parallel. In an ambiguous sentence, all sources of information are activated simultaneously and compete with each other until a certain threshold is reached (Van Gompel, & Pickering, 2000). However, some supporters of principle-based models claim that syntactic and lexical ambiguity resolution are virtually different (e.g., Frazier, 1989; Van Gompel, & Pickering, 2000).

Both categories of approach have received empirical support. Numerous studies have been conducted to investigate L1 sentence processing based on the above-mentioned theories. As far as L2 processing is concerned, some researchers (Juffs & Harrington, 1996; Dussias & Scaltz,

2007) postulate that L2 learners have access to both syntactic and non-syntactic information during on-line processing, as native speakers do.

Clahsen and Felser (2006) proposed the Shallow Structure Hypothesis (SSH), which states that there is a substantial difference between L1 and L2 parsing. Though adult L2 learners rely strongly on lexical, semantic and pragmatic information as native speakers do, the effects of syntactic information on L2 processing is less obvious than that in L1 processing. According to the SSH (Clahsen & Felser, 2006), there are two different routes of language processing, full parsing route and shallow parsing route. The full parsing route involves information about grammar, symbolic or parsing rules of the target language, while the input of the shallow parsing route is the lexical-semantic or conceptual knowledge. Native speakers employ these two routes in parallel to process sentences; however, shallow parsing route prevails L2 learners' processing. It is therefore suggested that even highly proficient L2 speakers may not be able to activate full syntactic information during sentence processing. Researchers have provided evidence that adult L2 speakers underuse syntactic information during parsing (Felser, Roberts, & Marinis, 2003). Evidence supporting shallow parsing route in L2 has been found in studies investigating how L2 learners of different L1 backgrounds resolve syntactic ambiguity (Felser, et al., 2003). Chen's (2005) study partially supports the SSH, in that advanced learners mainly used structural information, while less-advanced learners tended to integrate syntactic and non-syntactic information.

Syntactic ambiguity resolution strategies

Based on the empirical evidence from parsing syntactically ambiguous sentences, at least three general processing strategies were proposed to interpret the sentence in a more effective way.

1) Active Filler Strategy (Clifton & Frazier, 1989) postulates that the filler should be assigned as soon as possible. In a relative clause (RC) containing filler-gap dependency, whether the parser resolves for RC modifying subject (SRC) or RC modifying object (ORC) depends on different degrees of difficulty in identifying the filler and gap (Lin, 2006). Readers tend to integrate a filler with the earliest grammatically possible gap. The processing advantage of SRC over ORC is likely to occur because readers resolve the sentence by using Active Filler Strategy to arrive the suitable interpretation.

2) Minimal Attachment Strategy (Frazier, 1987) states that the parser prefers the simplest structure. No potentially unnecessary nodes will be processed. In the initial stage, only syntactic information is taken into consideration. When employing Minimal Attachment Strategy, readers adopt the analysis containing the fewest nodes in a syntactic mental representation. This strategy has been used to explain how readers resolve Main Verb/Reduced Relative Clause (MV/RRC) ambiguity in sentence such as *The tired soldiers warned about the dangers attacked the enemy again* (Example from Rah & Adone, 2010). Under the guidance of Minimal Attachment Strategy, the reader tends to interpret *warned* as the main verb because this structure requires no additional syntactic node as required by the analysis of treating *warned* as part of a relative clause.

3) Late Closure Strategy (Frazier, 1987) postulates the attachment of new item to the clause or

phrase currently being parsed. In processing a syntactic structure containing a complex NP of the type N1-of-N2 followed by a relative clause, such as in the sentence *The scientist explained the theory to the professor of the student who was in the corridor*, the parser may encounter two different kinds of interpretation. The RC *who was in the corridor* can be considered as a modifier of the professor (e.g. N1) or a modifier of the student (e.g. N2). Resolutions of the first kind are referred to *N1 attachment*, *Early Closure*, or *high attachment*, while the latter kind of interpretation is labeled *N2 attachment, Late Closure, or low attachment* (Dussias, 2003). By applying Late Closure Strategy, the readers may integrate the newly coming information of RC with prior materials, in order to prevent L2 memory capacity from overloading in the process of ambiguity resolution.

Previous research reveals that L2 learners of English apply similar strategies as native speakers. Despite the indication that L2 learners are also sensitive to syntactic information of processing ambiguous sentences, the extent to which the L2 syntactic information is available for the ambiguity resolution remains to be determined. A large number of studies on L1 syntactic ambiguity resolution have investigated how adult speakers process sentences of filler-gap dependencies. Given that a syntactic "gap" is not present in the input signal, the position of a gap can only be inferred indirectly. Upon identification of a gap, the filler will be retrieved from working memory and integrated with the subcategorizer of the structure.

Another aspect which receives considerable attention among the literature of ambiguity resolution is the research on learners' processing of non-syntactic animacy information which has been identified as a major source of processing difficulty among language learners (MacDonald et al., 1994). In their study, Gennari and MacDonald (2008) have found that an animate object relative clause (ORC) was more difficult than an inanimate ORC, because more possible interpretations can be identified with the reading of an animate head of a given ORC than the reading of an inanimate ORC head. In other words, if learners may use the cue of animacy information, it may better help them to understand the sentence.

In a recent study, Lai (2009) investigated real time processing of filler-gap dependencies involving the variables of animacy and word frequency. A group of native English readers was compared with two groups of Chinese-speaking EFL learners at advanced and intermediate levels. The results countered Clahsen and Felser's (2006) Shallow Structure Hypothesis by revealing that L2 learners were able to employ both syntactic and lexical-semantic information just like the native readers.

In sum, the issue whether L2 learners use syntactic versus non-syntactic information to resolve syntactic ambiguities remains controversial. Investigating how learners resolve syntactic ambiguities may provide us insight into their reading comprehension problems, based on which the instructor may provide a better explanation to improve students' reading comprehension. The present study addresses this issue by investigating strategy use of Chinese-speaking EFL learners to resolve syntactic ambiguities. Specifically, two syntactic aspects, filler-gap dependency and local syntactic ambiguity between main verb (MV) vs. reduced relative clause (RRC), were studied. Non-syntactic information, such as animacy of RC heads, noun phrase

(NP) attachment and plausibility of the noun were also taken into account. Two research questions are raised as follows:

1. What kind of strategies do Chinese-speaking EFL learners use to resolve syntactic ambiguity?
2. What is the contribution of syntactic and non-syntactic information to syntactic ambiguity resolution among Chinese-speaking EFL learners?

Method

Subjects

The participants of the present study were 114 Chinese-speaking EFL learners at a university in Taiwan, who were majoring in English. All subjects had studied English for at least six years in high schools, and were enrolled in junior English linguistics courses. Their mean age was 21.3 years (range = 20-25, SD = 6.3). All participants were naïve with respect to the purpose of the study.

Materials

To achieve the goal of the study, a series of tasks that contain four parts of experimental sentences were constructed. The tasks of testing syntactic ambiguity resolution are described below (see Appendix 1).

Filler-gap dependency in full RC

In this section, four sentence patterns were constructed to examine whether the filler-gap dependency was formed and modulated by both/either syntactic (e.g., Active Filler Strategy: Frazier, 1987) and/or lexical-semantic information (e.g., animacy of sentential subjects: *musician* vs. *accident*) during L2 reading. The items were designed using the conditions similar to that used in Lai's (2009) study. Four sentence patterns included animate RC head-subject-extracted RC (SRC), inanimate RC head-subject-extracted RC (SRC), animate RC head-object-extracted RC (ORC) and inanimate RC head-object-extracted RC (ORC). There were five sentences for each of the four conditions/patterns. Participants were asked to decide whether they considered a sentence to be a grammatical or ungrammatical English sentence.

RRC and Main Verb construction (RRC/MV)

This sentence pattern was designed to examine whether the local syntactic ambiguity is resolved and moderated by syntactic information (e.g., Minimal Attachment Strategy: Frazier, 1987). The materials were constructed based on the sentences borrowed from MacDonald's (1994), Juffs (1998) and Rah & Adone's (2010) research. There were ten sentences in this section. Participants were required to identify the main verb of each sentence item. It is predicted that the EFL

learners tend to identify the past participle in the RRC as the main verb of the clause by applying MAS.

RC with NP attachment

The syntactic structure under investigation in this section was similar to that used in Dussias (2003), which contained a complex NP of type N1-of N2 followed by a relative clause, as in *The scientist explained the theory to the professor of the student who was in the corridor*. There are several possible interpretations. The RC *who was in the corridor* can be parsed as a modifier of the first noun *the professor* or the second noun *the student* of the complex NP. The first kind of resolution has been referred to as *early closure*, or *high attachment*, because the first position of the NP is located at a higher point in the syntactic tree, whereas the latter kind of attachment is labeled *late closure*, or *low attachment*. Frazier (1987) assumed that the learner would attach new items to the clause or phrase that is currently under processing. According to this assumption, it is predicted that EFL learners would attach the RC to the second NP by employing the strategy of *late closure*. In this task, the participants were requested to identify whether the 'who' relative clause should be attached to NP1 or NP2.

Implausible/plausible NN-RC item ambiguous

In this section, the contributions of syntactic and nonsyntactic factors to the resolution of ambiguities were explored. The items were adapted from the noun-noun (NN)/relative clause (RC) conditions used in the study of Grodner, Gibson & Tunstall (2002). The plausibility of the NN construction was manipulated as nonstructural factor to support the RC reading. In Grodner et al.'s (2002) study, a number of nonsyntactic factors were strictly evaluated, such as plausibility, lexical frequency and referential parsimony. Twenty sentences were selected from Grodner et al.'s experiment. Among them, ten sentenced contained an implausible NN structure which leads to a less plausible interpretation of the NN than RC. For the other half of the items, the plausible NN items, contained NN readings that were more plausible than their RC interpretations. Because the focus of this section was the implausible NN items, it was necessary to control nonstructural influences which wouldn't support the NN reading in these items. Participants were required to answer one comprehension question following each item, namely, 'What is the subject of the sentence?' Twenty multiple choice questions were designed

Procedure

In order to demonstrate that the subjects had no vocabulary problems in the sentence items, one pilot study was conducted to a group of 15 students who did not take part in the survey. Items in which the students had vocabulary problems with were replaced. The revised version was used for the present study. The sentences were presented in a pseudorandomized order, in such as way that no two sentences of the same structure directly followed one another. The survey was employed in pencil-and-paper version and distributed in the linguistics course which

the subjects were taking. Participants took approximately 30 minutes to complete the task. They were instructed to answer the questions based on their linguistics knowledge.

Results

Accuracy of each sentence pattern

The students' answers to each sentence pattern in the questionnaire are presented in Table 1. The overall performance of the students showed that the students' level of ambiguity resolution was intermediate, nearly 60%.

Table 1.
Mean accuracy, percentage and standard deviations of each sentence pattern

	Sentence patterns		Maximum Score	%	Mean	SD
1	SRC/ORC-Animancy	SRCORC	20	79%	15.76	2.30
1.1	SRC-Animate	AnSRC	5	85%	3.79	1.02
1.2	SRC-Inanimate	InSRC	5	85%	3.51	1.11
1.3	ORC-Animate	AnORC	5	76%	4.23	0.82
1.4	ORC-Inanimate	InORC	5	70%	4.23	0.92
2	RRC vs. MV	MV	10	58%	5.77	2.81
3	RC-NP1-NP2	NP1NP2	10	45%	4.53	2.58
4	NN-RC	NN	20	47%	9.36	4.60
4.1	Implaus-NN-RC	ImpNN	10	49%	4.93	2.71
4.2	Plaus-NN-RC	PluNN	10	44%	4.43	2.20
		Average		59%	35.42	7.27

Note. SRC: RC head-subject-extracted; ORC: RC head-object-extracted; RRC: Reduced relative clause; MV: Main verb; Implaus-NN-RC: Implausible noun-noun relative clause; Plaus-NN-RC: Plausible noun-noun relative clause.

The subjects received the highest accuracy rate (85%) in the section of RC head-Sbject-extracted (SRC) structure and the lowest accuracy rate (47%) in the Implausible/plausible NN-RC items, which indicated the students had the most difficulty with the NN-RC structures. The general performance of the students in the tasks was compared by running one sample *t*-test. As shown in Table 2, this analysis yielded significant effects among all sentence patterns, except the comparison between NP1-NP2 vs. NN-structure (t = -0.289, p = 0.773).

Table 2.

Results of the t-test for the comparison among different sentence patterns

Sentence patterns	*t*	*df*	*Sig. (2-tailed)*
Filler-gap vs. Main Verb	20.344	114	0.012***
Filler-gap vs. NP1-NP2	31.552	114	0.003***
Filler-gap vs. NN-structure	30.618	114	0.021***
Main Verb vs. NP1-NP2	4.862	114	0.034***
Main Verb vs. NN-structure	4.480	114	0.001***
NP1-NP2 vs. NN-structure	-0.289	114	0.773

Note. *p < .05; ** p < .01; ***p < .001

The purpose of testing the filler-gap dependency in full RC structure was to investigate whether syntactic information (subject vs. object position in the relative clause) and lexical information (animacy) might affect students' resolution of syntactic ambiguity. One sample *t*-test was used to test the effect of syntactic and lexical information. The results of the *t*-test indicated that there was a significant difference between SRC and ORC structures (t = 7.574, df = 114, p = 0.000), whereas no difference was found between animate and inanimate structures (t = 1.726, df = 114, p = 0.087).

In the section of RRC vs. Main Verb Structure, the task was to identify the main verb. It is predicted that the EFL learners tend to identify the past participle in the RRC as the main verb of the clause by applying Minimal Attachment Strategy (MAS). For example, the main verb of the sentence 'The famous man invited by every student was a very nice person' is 'was', but the subjects might choose 'invited' because of MAS. The accuracy rate of this section was 58%. The result of one sample *t*-test verified that the majority of the students chose the correct main verb, instead of the past participle (t = 6.007, df = 114, p = 0.000), indicating that the subjects did not obviously apply MAS.

The purpose of the section of RC-NP1-NP2 is to test the strategy of late closure. It is predicted that the subjects would attach the RC to NP2 by employing the late closure strategy. In

this section, the participants were requested to identify whether the relative pronoun 'who' should be attached to NP1 or NP2. For example, in the sentence '*The guard told the boss of the reporter who heard about the story*', the '*who*' relative clause would be attached to the second NP '*the reporter*', by applying late closure strategy. The results showed that the percentage of the subjects choosing NP2 was 45%, the lowest among all sentence patterns. One sample *t*-test was conducted and the result confirmed the participants' choice of NP1 over NP2 ($t = 4.025$, df = 114, $p = 0.000$).

The construction of the Implaus/Plaus-NN-RC structure was to investigate the contribution of lexical information of plausibility to ambiguity resolution. The participants were required to identify the subject of the sentence. For example, the subject of the sentence 'The cafeteria students frequently eat at serves both vegetarian and kosher meals', is supposed to be 'the cafeteria'. Two sets of conditions, implausible and plausible NNs, were taken into consideration. Significant difference is to be found between these two conditions, if there is an effect of plausibility. The average accuracy rate of this subtest was only 47%, suggesting that they students had certain degree of difficulty with identifying the subject of the sentence, even with the information of plausibility. Although the accuracy rate for the plausible NN-RC structure was slightly lower than the implausible NN-RC structure, there was no significant difference between these two conditions ($t = 2.099$, df = 114, $p = 0.051$).

The processing of syntactic and non-syntactic information

In order to see the contribution of syntactic and non-syntactic information to overall resolution of syntactic ambiguities, Pearson Correlation between each section and the overall performance was conducted. The results in Table 3 showed that each section was significantly correlated with the overall performance. Specifically, section 2 (RRV/MV) and 3 (RC-NP1-NP2) are related to syntactic information.

Table 3.
Correlation between each section with overall performance

	1. Filler-Gap	2. RRV/MV	3. RC-NP1-NP2	4. NN-RC	Total
1. Filler-Gap	1	.353(**)	-.034	.076	.435(**)
2. RRV/MV	.353(**)	1	-.074	.222(*)	.691(**)
3. RC-NP1-NP2	-.034	-.074	1	.061	.484(**)
4. NN-RC	.076	.222(*)	.061	1	.619(**)
Total	.435(**)	.691(**)	.484(**)	.619(**)	1

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Section 4 (implausible/plausible NN-RC) are related to non-syntactic information. And section 1 (Filler-Gap) was both related to syntactic (filler dependency) and non-syntactic (animacy) information. Moreover, the results of one sample *t*-test showed that there was difference between section 3 (RC-NP1-NP2) and section 4 (NN-RC) (t = -0.289, p = 0.773), which indicated no difference between syntactic and non-syntactic information.

Discussion

In the present study, we have investigated whether the EFL readers employed Active Filler Strategy (AFS), Minimal Attachment Strategy (MAS) or Late Closure Strategy (LCS) to resolve syntactic ambiguities.

Firstly, the processing advantage of SRC over ORC is likely to occur, if the readers resolve the sentence by using AFS. The results of the section of filler-gap sentence pattern showed that the accuracy rate of SRC structure was significantly higher than ORC structure. In other words, the subjects tended to judge sentences with SRC structures as correct. This indicates that the readers resolved the ambiguity of filler-gap dependency sentences by applying AFS. Our results generally are in accordance with the SRC preference in that (in)animate SRCs were judged overall more easily than ORCs, as found in the studies of Chen (2005). Though the subjects had slightly more struggle with inanimate ORCs than animate ORCs, there was no significant difference between animate and inanimate items.

Secondly, the readers resolve Reduced Relative Clause/Main Verb (RRC/MV) ambiguities by adopting MAS, if they interpret the past participle as the main verb. The results of the second section (RRC vs. MV) showed that the majority of the subjects chose the main verb correctly. The tendency that they chose the main verb, instead of the past participles in the RRC clause suggests that they did not employ MAS as predicted by Dachevski (2005).

Thirdly, in a RC-NP1-NP2 structure, a reader tends to attach NP2 to *who*-RC starting with *who* because of using LCS. It is predicted that the reader would interpret *who*-RC is modified by NP2. However, the results of the present study do not support the prediction proposed by Dussias (2003) by showing the subjects' preference of NP1 over NP2. In Dussias's study, English native speakers showed a preference for low attachment of an RC to NP2, whereas the EFL learners did not show this tendency in the present study. This finding is demonstrated in the second section, that the percentage of choosing NP1 was significantly higher than that of NP2, indicating the subjects did not necessarily use LCS.

The results of the Pearson Correlation showed that each section was strongly correlated with the subjects' overall performance of ambiguity resolution. This provides preliminary support for the hypothesis that both syntactic and non-syntactic information are influencing the subjects' resolution of syntactic ambiguities. No effect of non-syntactic information, e.g. animacy and plausibility information, was found in section 1 and 4 respectively. Furthermore, one sample T-test indicated that the difference between section 3 (RC-NP1-NP2) and section 4

(NN-RC) was not statistically significant (t = -0.289, p = 0.773). The data reveals that there is no difference between the subjects' processing of syntactic and non-syntactic information.

In general, the results of this study are in favor of constraint-based model in the sense of MacDonald et al. (1994) because both syntactic and non-syntactic information were involved. In accordance with the results in Lai's (2009) studies, the results reveal that the participants' access to both kinds of information is parallel and interactive. Furthermore, similar to the Chen's (2005) findings, this study also partially supports the Shallow Structure Hypothesis (SSH) proposed by Clahsen and Felser (2006) which postulates that there are substantial differences between L1 and L2 parsing, suggesting the use of different strategies in L1 and L2. In Chen's (2005) study, advanced Chinese-speaking learners of English adopted more structural information, while less-advanced learners tended to integrate syntactic and non-syntactic information. In this study, although the participants showed a bias for using Active Filler Strategy, there is no evidence of their use of Minimal Attachment Strategy or Late Closure Strategy. In other words, comparing to ORCs, it is easier for them to recognize the filler dependency in SRCs. Nevertheless, there is no consistent evidence of applying the strategy of low attachment, as observed among L1 speakers. One interesting phenomenon is that some subjects had received ceiling scores in the first three sections in which syntactic information was mainly considered, but their performance was extremely low, or even zero in the fourth section, in which non-syntactic information was involved. The discrepancy of performance indicates that these students are indeed sensitive to the type of structural and non-structural information that directs the parser to make the judgment of ambiguity resolution. However, they are somehow confused by different kinds of information. It should also be noted that the subjects of the present study did not achieve the overall accuracy rate at a satisfying level, indicating that they were less proficient readers of English. The interference or interaction of different kinds of information may cause their confusion and then the overload of processing the information may lead to lower accuracy rate.

Conclusion

The results of the present study reveal two major findings. First, the L2 learners in this study did not necessarily employ the same strategies to resolve syntactic ambiguity as in L1. The subjects' preference of SRC over ORC structures indicates the employment of Active Filler Strategy (Clifton & Frazier, 1989); however, no direct evidence of the usage of Minimal Attachment Strategy (Dachevski, 2005; Rah & Adone, 2010) and Late Closure Strategy (Frazier, 1987; Dussias, 2003) is found. In this concern, the findings of the present study partially support the claim that L2 learners apply similar processing strategies as native speakers. Second, positive correlations are found between each section and overall performance, indicating that both syntactic and non-syntactic information have influenced the subjects' syntactic processing of ambiguities. Furthermore, the result that no difference exists between syntactic and non-syntactic information suggests a parallel and interaction activation of difference sources of information. This finding is therefore consistent with the predictions of constrain-based processing theories.

In conclusion, in spite of the limitations of this study, namely, the single group design and the use of an off-line task to investigate L2 sentence processing, this study presents specific findings in that it shows that intermediate Chinese learners of English use both syntactic and non-syntactic information in resolving syntactic ambiguities. Although off-line tasks might not be as objective as on-line tasks, the findings of this study provide straightforward information about what might occur in real situation. Further research with learner groups of various proficiency levels is thus necessary to better understand the mechanism and difficulties of L2 learners' syntactic ambiguity resolution.

About the author

Dr. Yea-Ru Tsai is an associate professor of Applied English Department at I-Shou University. She has taught reading, writing, and applied linguistics in Taiwan. Her major research interests include computer assisted reading and writing instruction, psycholinguistics, and English for specific purposes.

References

Binder, K. S., Duffy, S. A., & Keith, R. (2001). The effects of thematic fit and discourse context on syntactic ambiguity resolution. *Journal of Memory and Language*, *44*, 297-324.

Chen, C. H. (2005). Chinese L2 learners' use of structural and lexical information in processing English subject and object relative clauses. *Proceedings of the 2005 annual conference of the Canadian Linguistic Association*.

Clahsen, H., & Felser, C. (2006). Grammatical processing in language learners. *Applied Psycholinguistics, 27*, 3-42.

Clifton, C., & Frazier, L. (1989). Comprehending sentences with long-distance dependencies. In G.N. Carlson, & M. K. Tanenhaus (Eds.), *Linguistic structure in languages processing* (pp. 273-317). Dordrecht: Kluwer.

Dachevski, L. (2005). Thematic fit and syntactic ambiguity resolution of intransitive main clauses. Proceedings of the 2005 annual conference of the Canadian Linguistic Association, pp. 1-12.

Dussias, P. E. (2003). Syntactic ambiguity resolution in L2 learners. *Studies in Second Language Acquisition. 25*, 529-557.

Dussias, P.E., & Scaltz, C. (2007). Spanish-English L2 speakers' use of subcategorization bias information in the resolution of temporary ambiguity during second language reading. *Acta Psychologica*, *128*, 501-513.

Felser, C., Roberts, L., & Marinis, T. (2003). The processing of ambiguous sentences by first and second language learners of English. *Applied Psycholinguistics, 24*, 453-489.

Frazier, L. (1987). Theories of sentence processing. In J. Garfield (Ed.), *Modularity in knowledge representation and natural language understanding* (pp. 291-307). Cambridge, MA: MIT Press.

Frazier, L. (1989). Against lexical generation of syntax. In W.D. Marslen-Wilson (Ed.) *Lexical representation and process* (pp. 529-561). Cambridge, MA: MIT Press.

Frazier, L., & Clifton, C. (1996). Construal: Overview, motivation, and some new evidence. *Journal of Psycholinguistic Research, 26*(3), 277-295.

Gennari, S. P., & MacDonald, M. C. (2008). Semantic indeterminacy in object relative clauses. *Journal of Memory and Language, 58*(2), 161-187.

Grodner, D., Gibson, E., & Tunstall, S. (2002). Syntactic complexity in ambiguity resolution. *Journal of Memory and Language, 46*, 267-295.

Juffs, A., & Harrington, J. (1996). Garden path sentences and error data in second language sentence processing. *Language Learning, 46*, 283-326.

Lai, Y. D. (2009). *Processing relative clauses in English as L2: An on-line study*. Unpublished doctoral dissertation of National Taiwan Normal University.

Lin, C. –J. (2006). Grammar and Parsing: A Typological Investigation of Relative-Clause Processing. Unpublished doctoral dissertation of the University of Arizona.

MacDonald, M. C. (1994). Probabilistic constraints and syntactic ambiguity resolution. *Language and Cognitive Processes, 9*, 121-136.

MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). Syntactic ambiguity resolution as lexical ambiguity resolution. In J. C. Clifton, L. Frazier, & K. Rayner (Ed.), *Perspectives on sentence processing*. Hillsdale, N.J.: Erlbaum.

Rah, A., & Adone, D. (2010). Processing of the reduced relative clause versus main verb ambiguity in L2 learners at different proficiency levels. *Studies in Second Language Acquisition*, *32*, 79-109.

Snedeker, J., & Trueswell, J. C. (2004). The developing constraints on parsing decisions: The role of lexical-biases and referential scenes in child and adult sentence processing. *Cognitive Psychology*, *49*, 238-299.

Van Gompel, R. P. G., & Pickering, M. J. (2000). Unrestricted race: A new model of syntactic ambiguity resolution. In: A. Kennedy, R. R. Radach, D. Heller, & J. Pynte (Eds.), *Reading as a perceptual process* (pp. 621-648). Oxford: Elsevier.

Vosse, T., & Kempen, G. (2009). In defense of competition during syntactic ambiguity resolution. *Journal of Psycholinguistic Research*, *38*, 1-9.

Appendix A. Tasks of syntactic ambiguity resolution

Part 1. Please judge the grammaticality of the sentences in each item. (G: grammatical; U: ungrammatical)

	G	U
1. The musician that witnessed the accident angered the policeman a lot.		
2. The contestant that the prize delighted impressed Mary a lot.		
3. The pistol that injured the cowboy was known to be reliable.		
4. The climate that the scientist studied did not interest the reporter.		
5. The woman that reported the accident caused a number of serious injuries.		
6. The doctor that printed the notes got lost somewhere in the hospital.		
7. The director that the show leased received a prize at the movie festival.		
8. The school that educated the student was visited by the governor.		
9. The show that the teacher watched upset a few of the students.		
10. The child that the gun scared injured the babysitter.		
11. The salesman that examined the product was mentioned in the letter.		
12. The firemen that the fire burned caused only a small amount of damage.		
13. The loan that worried the banker created a problem for the mayor.		
14. The term paper that the professor reviewed is terrible.		
15. The project that pleased the salesman was raised for discussion in today's meeting.		
16. The gardener that trimmed the plants helped make the house more attractive.		
17. The actor that the play recruited was given first prize at the awards dinner.		
18. The instrument that attracted the student had been around for a few months.		
19. The game that the player mastered was ignored by most sportswriters.		
20. The article that the journalist composed caused a big scandal.		

Part 2. Identify the main verb in the following sentences.

	Answer
1. The tired soldiers warned about the dangers attacked the enemy again. What is the main verb of this sentence? A) attacked B) warned	
2. The brown sparrow noticed on an upper branch pecked at an insect. What is the main verb of this sentence? A) noticed B) pecked	
3. The famous man invited by every student was a very nice person. What is the main verb of this sentence? A) was B) invited	
4. The small girl lost in the buzzing crowd looked for her parents. What is the main verb of this sentence? A) lost B) looked	
5. The brave fireman rescued from the burning roof saved the helpless people. What is the main verb of this sentence? A) saved B) rescued	
6. The angry boy hit in the football pitch was full of bruises. What is the main verb of this sentence? A) was B) hit	
7. The black dog found in his garden hut barked at the postman. What is the main verb of this sentence? A) found B) barked	
8. The strict teacher criticized in his English course held a boring lesson. What is the main verb of this sentence? A) held B) criticized	
9. The small sharks caught in the fishing net were very aggressive. What is the main verb of this sentence? A) caught B) were	
10. The old woman visited in the rose garden liked gossip very much. What is the main verb of this sentence? A) liked b) visited	

Part 3. Identify the noun whom the pronoun who refers to.

	Answer
1. Peter fell in love with the daughter of the psychologist who studied in California. What does "who" refer to? A) the daughter B) the psychologist	
2. The dog bit the sister of the teacher who lived in Paris. What does "who" refer to? A) the teacher B) the sister	
3. The doctor was looking at the friend of the nurse who is talking on the phone. What does "who" refer to? A) the friend B) the nurse	
4. The manager sent flowers to the daughter of the secretary who plays piano well. What does "who" refer to? A) the secretary B) the daughter	
5. The scientist explained the theory to the professor of the student who was in the corridor. What does "who" refer to? A) the student B) the professor	
6. The guard told the boss of the reporter who heard about the story. What does "who" refer to? A) the boss B) the reporter	
7. The teacher visited the parent of the student who was angry about the accident. What does "who" refer to? A) the student B) the parent	
8. The director refused the husband of the actress who proposed the show. What does "who" refer to? A) the husband B) the actress	
9. The author told a story to the child of the reader who was living in the hospital. What does "who" refer to? A) the reader B) the child	
10. The driver drank with the son of the pub owner who was standing at the bar. What does "who" refer to? A) the son B) the pub owner	

Part 4. Read the following sentences and answer the multiple-choice questions. There is only one correct answer in each item.

	Answer
1. The country enemies may soon attack decided to increase military spending and tighten restrictions on immigration. What is the subject of this sentence? A) the country B) enemies C) the country enemies D) military	
2. The park dogs can play in is beside the pond near the railway station. What is the subject of this sentence? A) dogs B) the park C) the pond D) the park dogs	
3. The appliance cats tend to damage is a dishwasher that vibrates too much. What is the subject of this sentence? A) the appliance cats B) dishwasher C) the appliance D) cats	
4. The doll children like to have is a Barbie doll of one kind or another. What is the subject of this sentence? A) Barbie B) the doll children C) children D) the doll	
5. The warranty televisions usually come with is for one year but includes no labor. What is the subject of this sentence? A) the warranty B) televisions C) the warranty televisions D) labor	
6. The cafeteria students frequently eat at serves both vegetarian and kosher meals. What is the subject of this sentence? A) the cafeteria B) students C) the cafeteria students D) vegetarian	
7. The doctor women will rely on is a skilled physician who listens carefully to their problems. What is the subject of this sentence? A) women B) the doctor C) physician D) the doctor women	
8. The newspaper neighbors frequently argue over is the local community paper delivered on Wednesday afternoon. What is the subject of this sentence? A) the newspaper neighbors B) the local community	

C) the newspaper D) neighbors

9. The inn businessmen can stay at provides bagels for breakfast along with orange juice and coffee.

   What is the subject of this sentence?

   A) bagels B) the inn businessmen C) businessmen D) the inn

10. The stroller mothers prefer to push has large rubber wheels and a good breaking system.

    What is the subject of this sentence?

    A) mothers B) the stroller C) system D) the stroller mothers

11. The kitchen lamps shine brightest in is one with lost of white tile and little dark wood.

    What is the subject of this sentence?

    A) the kitchen B) lamps C) the kitchen lamps D) wood

12. The shirt hooks tend to rip is made of fine silk and is quite delicate.

    What is the subject of this sentence?

    A) hooks B) the shirt C) silk D) the shirt hooks

13. The coat shops are now advertising is being marketed to young professionals.

    What is the subject of this sentence?

    A) the coat shops B) professionals C) the coat D) shops

14. The egg boxes will not crush possesses a shell that is half an inch thick.

    What is the subject of this sentence?

    A) shell B) the egg boxes C) boxes D) the egg

15. The jacket pockets are sewn on is good for keeping your hands warm though it isn't very fashionable.

    What is the subject of this sentence?

    A) the jacket pocket B) hands C) the jacket D) pockets

16. The beach trucks are driven on is less than a mile from the beach where people swim.

    What is the subject of this sentence?

    A) the beach B) trucks C) the beach truck D) people

17. The commander pilots receive orders from wears two stars to display his high rank. What is the subject of this sentence? A) pilots B) the commander C) orders D) the commander pilots	
18. The restaurant tables are placed behind is trying to gain more business with outside seating. What is the subject of this sentence? A) the restaurant tables B) business C) the restaurant D) tables	
19. The desk pens write best on has a hard flat surface and plenty of space to spread papers out. What is the subject of this sentence? A)surface B) the desk pens C) pens D) the desk	
20. The school computers help to organize is running smoothly because administrators have less paperwork than they used to. What is the subject of this sentence? A) administrators B) the school computers C) computers D) the school	