

Developmental Trajectory of Relative Clauses among Mandarin Learners of English*

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In elucidating the difficulty of relative clause processing and acquisition, previous studies have mostly focused on two theories, i.e., Noun Phrase Accessibility Hierarchy and Perceptual Difficulty Hypothesis. In recent years, Gibson's Dependency Locality Theory proposed a detailed calculation regarding energy units spent at each position in a sentence and has drawn much attention and support in research. The present study tested the predictions of these three theories by looking at relative clause production in English compositions written by Mandarin-speaking EFL learners, including senior high school sophomores, senior high school seniors, college non-English majors, college first-year English majors, and college second-year English majors. Results show different levels of support for different theories, with each theory having its own strengths and weaknesses. Furthermore, the results also clearly indicate that when the L2 proficiency of Mandarin-speaking EFL learners increases, the learners exhibit better control over the production of relative clauses in their compositions.

Key words: relative clause, psycholinguistics, sentence production

1. Introduction

Comprehension and production have been viewed as two major components in language learning. During comprehension, language learners map the spoken or written input onto their mental lexicon, build a syntactic construction and then derive meaning. During production, they conceptualize the message, encode lexical, grammatical and phonological forms, and finally articulate the sounds. A recent trend in second language research has tried to examine second language comprehension using relative clauses since they help shed light on the cognitive processes of language learners. To date, different theoretical proposals, discussed in more detail below, have been offered to explain processing and acquisition difficulties (e.g. Hsiao & Gibson 2003, O'Grady, Lee & Choo 2003, Hsu 2014a, 2014b, Hsu & Lin 2014). However, relative clause production, especially in naturally occurring data, has received relatively less attention. It should be noted that second language production has been considered to be arduous (Ellis 1985, Ringbom 1992) and examining naturally occurring relative clauses is of great value since, on the one hand, it offers researchers a chance to re-examine the validity of theoretical accounts and, on the other hand, it offers further insights into the difficulties of different types of relative

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clauses. The current study thus tried to examine the production of relative clauses in English written by Mandarin learners of English. Before describing the methodological issues, I will first introduce syntactic constructions of relative clauses and the theoretical accounts associated with them.

The syntactic constructions of relative clauses are illustrated below:

(1) a. Object relative clause

[NP The student_{*ti*} [CP who [TP the teacher liked *ti*]]] won the competition.

b. Subject relative clause

[NP The student_{*ti*} [CP who [TP *ti* liked the teacher]]] won the competition.

The examples above show that, apart from inside the relative clause region where the relative verb, *liked*, and the noun phrase, *the teacher*, are reversed, these two sentences are identical. Depending on the function of the head noun, in this case *the student*, relative clauses can be separated into either subject relative clauses or object relative clauses. For subject relative clauses, the head noun is the doer of the action inside the relative clause region while for object relative clauses, the head noun is the recipient of the action. What makes these two constructions especially interesting for researchers is that even though they look extremely similar, asymmetrical processing and production difficulties exist between them. Numerous studies across many languages have found that subject relative clauses are easier to comprehend than object relative clauses both in English and in many other languages (Carpenter, Miyake & Just 1994, Gibson 1998, Caplan & Waters 2002).

Example (1) illustrates the condition when the relative clause region modifies the matrix subject. Note that it is also possible for the relative clause to modify the matrix object, as illustrated by example (2):

(2) Relative clause modifying the matrix object

a. Object relative clause

The teacher liked the student [who the girl liked].

b. Subject relative clause

The teacher liked the student [who liked the girl].

Furthermore, the subject and object relative clauses in the above examples are illustrations of relativizing subject and object positions inside the relative clauses. In fact, nouns can be relativized at different positions in a sentence, resulting in different types of relative clauses. The following table illustrates relativization positions in a sentence.

Table 1. Relativization position modifying matrix subject and object positions

<i>Relative clause modifying position</i>	<i>Relativization position</i>	<i>Examples</i>
Matrix subject	Subject	The man who invited Mary was Tom.
	Direct Object	The man who Mary invited was Tom.
	Indirect Object	The man who Mary gave a book to was Tom.
	OPREP (Oblique)	The man who Mary talked to was Tom.
	Genitive	The man whose wife was Mary was Tom.
	SCOMP	The man who was smarter than Mary was Tom.
Matrix object	Subject	The man liked the girl who invited Mary.
	Direct Object	The man liked the girl who Mary invited.
	Indirect Object	The man liked the girl who Mary gave a book to.
	OPREP (Oblique)	The man liked the girl who Mary talked to.
	Genitive	The man liked the girl whose mother was Mary.
	SCOMP	The man liked the girl who was smarter than Mary.

Note that even though relative clauses are more complex than other kinds of syntactic structures, it is a cross-linguistic phenomenon which occurs in many different languages. Keenan & Comrie (1977), Comrie & Keenan (1979), and Comrie (1998) examined and compared relative clauses across many different languages and proposed a uniting account based on markedness to explain the increasing difficulty of relativizing noun phrases in different positions of a sentence: Noun Phrase Accessibility Hierarchy (NPAH), which is assumed to be a language universal property.

(3) Noun phrase accessibility hierarchy (NPAH)

Subject > Direct Object > Indirect Object > Oblique > Genitive > Object of Comparison

The sign “>” in the hierarchy indicates “easier than”. In this hierarchy, positions on the left are less marked than positions on the right. For example, relativizing objects of comparison are more marked than relativizing genitive positions. Comrie states, “Each position on the NPAH is justified empirically by the existence of at least one language that relativizes on that position but on no lower position” (Comrie 2007: 304). According to the NPAH, if a language can relativize indirect object positions,

for example, it can relativize every other position to its left, such as a subject or a direct object, but not on its right, such as a genitive. English and Arabic, for example, can relativize all positions in the hierarchy. French, Portuguese, Italian, Persian, Mandarin, Japanese and Korean can relativize almost all positions except for objects of comparison.¹ Thai can only relativize up to indirect object positions. Of the fifty languages that Keenan and Comrie examined, most conformed to the proposal of this hierarchy.

Even though this hierarchy was proposed to explain a universal property of language, it has implicational value on language acquisition and processes. Researchers have found that there seem to be correlations between the acquisition of relative clauses and the position of the relative clauses based on this hierarchy. Given that the subject position is the most accessible, the NPAH predicts that subject relative clauses are the easiest to acquire and process. Therefore, subject relative clauses are easier for people to acquire than object relative clauses, which in turn are easier than other types of relative clauses. Comrie (2007) revised the order in the NPAH as follows:

(4) Noun Phrase Accessibility Hierarchy (2007 version)

Subject > Direct Object > Other Object > Genitive/Possessor

For years, the NPAH has been used to examine first language acquisition and processing of relative clauses across many languages. For example, the hierarchy has been used to reflect the fact that subject relatives are easier to process since, according to the hierarchy, they are more accessible than object relative clauses. With respect to relative clause (RC) production, children in different languages have been found to produce more subject relative clauses earlier than object relative clauses (Keenan & Comrie 1977). However, predictions based on the NPAH were not borne out in some other studies, which have posed challenges to NPAH. For example, when examining relative clause production in Cantonese children, two studies (Matthews & Yip 2002, Yip & Matthews 2007) found that Cantonese-English bilingual children produced Cantonese object RCs earlier than subject RCs. The reason might be due to the fact that Cantonese object relative clauses actually have a SVO word order, which is similar to the canonical SVO word order in Cantonese.

Besides NPAH, another theoretical account which has been used to examine relative clause acquisition and processing difficulty is Kuno's Perceptual Difficulty Hypothesis (PDH) (Kuno 1974). This hypothesis looks at acquisition and processing

¹ Note that for Mandarin relative clauses involving resumptive pronouns, it is possible to relativize the object of comparison position. For example, it's possible to say *nage nanhai bi ta gao DE xuesheng* “*that student who the boy is taller than her”.

difficulty from the perspective of cognitive interruption. It can be illustrated by the following examples:

(5) Perceptual Difficulty Hypothesis (PDH)

- a. The cheese [the rat [the cat chased] ate] was rotten.
- b. The cat chased the rat [that ate the cheese [that was rotten]].

These two sentences are similar with respect to meaning while they are different with respect to the position of the relative clauses. The relative clauses are center-embedded in (a) while they are right-branching in (b). Kuno claimed that center-embedding relative clauses such as (a) are perceptually more difficult than (b) because for center-embedded relative clauses, comprehenders receive two or three noun phrases in a row first and then their predicates come afterwards. In the above example, comprehenders receive “the cheese”, “the rat” and “the cat” in a row and have to place them in the correct order in the working memory temporarily before they can further interpret the sentence. In order not to reduce the comprehensibility of (a), keeping track of the two or three noun phrases and their relationship with the predicate is a must. Given that there is a limitation on human working memory, keeping track of these noun phrases while interpreting the sentence will be cognitively more demanding.

Although Kuno did not deliberately examine the difficulty of relative clauses from the perspective of the role that the head noun plays, it is logical to infer that the PDH predicts that English object relative clauses will be harder since comprehenders also have to keep track of the relationship between two incoming noun phrases (e.g., “The student who the teacher likes is admitted.”) and this is cognitively more demanding than English subject relative clauses. A fully-crossed combination between the role that the head noun plays and the position that the relative clause modifies results in four subtypes, as illustrated by example (6). The first letter in the parenthesis indicates the role of the whole relative clause in the matrix. An initial S indicates that the relative clause is used to modify the matrix subject, as in (a) and (b). The second letter indicates the role of the head noun inside the relative clause, leading to either subject or object relative clauses. An S indicates that it is a subject relative clause. An O indicates an object relative clause.

- (6) a. [The student who liked the teacher] was coming back to school. (SS)
- b. [The student who the teacher liked] was coming back to school. (SO)
- c. The principal praised [the student who liked the teacher]. (OS)
- d. The principal praised [the student who the teacher liked]. (OO)

With respect to these four kinds of combinations, the PDH assumes that the order of difficulty is OS > OO > SS > SO. OS is easiest because the relative clause in the region does not interrupt the matrix clause and it also has a basic SVO word order. In other words, it poses almost no difficulty to comprehenders. The second easiest is OO because although the relative clause region does not interrupt the matrix clause, it has a non-canonical word order, which poses some difficulties to comprehenders. The most difficult is SO since the relative clause not only interrupts the matrix clause but also has a non-canonical word order.

Over the years, most studies examining the order of difficulty of relative clauses across languages have focused on testing the predictions of the NPAH and PDH. Some studies found full or partial support for the (Brown 1971, Gass 1979, 1980, Tarallo & Myhill 1983, Hyltenstam 1984, Pavesi 1986, Yip & Matthews 1991) while other studies found full or partial support for the PDH (Cook 1973, Ioup & Kruse 1977, Schumann 1980, Flanigan 1995). Note that there are also some studies which found mixed support for both accounts (Prideaux & Baker 1986, Bates, Devescovi & D'Amico 1999, Izumi 2003).

The PDH's rationale of using the human working memory system to capture sentential difficulty is similar to a later theoretical proposal, the Dependency Locality Theory. Gibson's (1998, 2000) Dependency Locality Theory (DLT) is a locality-based or distance-based theory of language comprehension and production. DLT has received much recognition and support from many studies focusing on the syntactic ambiguity or processing of relative clauses across different languages (e.g. Hsiao & Gibson 2003, Gibson & Warren 2004, Warren & Gibson 2005, Nakatani & Gibson 2010). It thus warrants greater attention and closer examination with respect to acquisition of relative clauses in first and second language speakers. According to DLT, since sentence comprehension and production involve moment-by-moment integration of a variety of different information while reading and listening to sentences, it assumes that resources are required for two aspects of structural parsing: structural integration and storage of temporary syntactic units, both of which are related to working memory demands and costs. Integration cost refers to the effort involved in linking new incoming words with the existing syntactic structure. According to the structural integration cost, processing a new discourse referent and the head of a VP that refers to a new discourse event consumes the most energy. Connecting a VP with an NP is cost-free since it is within comprehenders' expectations. Nevertheless, if there are intervening items between the VP and the NP, energy units will be consumed since working memory has to be active to keep previous items in the memory loop. Therefore, according to DLT, there will be a working memory cost during sentence comprehension.

Gibson gave specific calculations of energy consumption for English subject and object relative clauses. The following examples illustrate detailed calculations of energy consumption for both discourse referents and structural integration and the total consumption of units. In terms of a new discourse referent, one energy unit is consumed for each noun and verb, as indicated by “1” below all the nouns and verbs. For structural integration, each intervening noun and verb will consume one energy unit. For example, in (7a) below, the matrix clause is interrupted by the relative clause region and thus when comprehenders integrate “the boy” and “disliked”, two energy units are consumed due to the presence of “like” and “girl” in the relative clause. In (7b), structural integration occurs inside the relative clause region when the empty category, *e*, integrates with the filler. This is represented by the “2” under “liked.” The other structural integration occurs in the “disliked” region where the matrix clause is integrated. This is represented by the “2” under “disliked.” Note that no structural integration is needed if the structure involves a simple SVO order.

(7) Dependency Locality Theory

a. Subject relative clause

	The boy who liked the girl disliked the teacher.								
New discourse referent	0	1	0	1	0	1	1	0	1
Structural integration	0	0	0	0	0	0	2	0	0
Total (7)	0	1	0	1	0	1	3	0	1

b. Object relative clause

	The boy who the girl liked <i>e</i> disliked the teacher.								
New discourse referent	0	1	0	0	1	1	1	0	1
Structural integration	0	0	0	0	0	2	2	0	0
Total (9)	0	1	0	0	1	3	3	0	1

The number in parenthesis indicates the total energy units consumed for the whole sentence. Based on the units consumed at each word position, the DLT not only predicts that object relative clauses are more difficult but also indicates which positions create the most difficulty. This is indicated by the number of total cost at each position. The examples above clearly demonstrate why English object relative clauses are more difficult than English subject relative clauses. Since more structural integration costs are associated with object relative clauses, more energy units (9 units) are consumed for object relative clauses than for subject relative clauses (7 units).

Since DLT has laid out how to calculate the energy units for each step, it can be applied to the four basic types of relative clauses. Detailed calculations of energy consumption for center-embedded versus right-branching relative clauses are given as follows:

(8) a. Subject relative clause (right-branching) (OS)

	The boy disliked the teacher who liked the girl.								
New discourse referent	0	1	1	0	1	0	1	0	1
Structural integration	0	0	0	0	0	0	0	0	0
Total (5)	0	1	1	0	1	0	1	0	1

b. Subject relative clause (center-embedded) (SS)

	The boy who liked the girl disliked the teacher.								
New discourse referent	0	1	0	1	0	1	1	0	1
Structural integration	0	0	0	0	0	0	2	0	0
Total (7)	0	1	0	1	0	1	3	0	1

(9) a. Object relative clause (right-branching) (OO)

	The boy disliked the teacher who the girl liked <i>e</i> .									
New discourse referent	0	1	1	0	1	0	0	1	1	
Structural integration	0	0	0	0	0	0	0	0	2	
Total (7)	0	1	1	0	1	0	0	1	3	

b. Object relative clause (center-embedded) (SO)

	The boy who the girl liked <i>e</i> disliked the teacher.									
New discourse referent	0	1	0	0	1	1	1	0	1	
Structural integration	0	0	0	0	0	2	2	0	0	
Total (9)	0	1	0	0	1	3	3	0	1	

The above examples show DLT's calculations of energy units consumed for each of the basic four types of relative clauses. In general, center-embedded relative clauses consume more energy units than right-branching ones. Therefore, center-embedding relative clauses are supposed to be more difficult for comprehenders than right-branching relative clauses. Thus the order of difficulty for these four types of relative clauses is: OS > OO = SS > SO.

The following examples illustrate DLT's calculations for other types of relative clauses: indirect object relative clauses, object of preposition relative clauses, genitive relative clauses, subject and object of comparison relative clauses.

(10) a. Indirect object relative clause (center-embedded)

The boy who the girl gave the book to *e* disliked the teacher.

New discourse referent	0	1	0	0	1	1	0	1	0	1	0	1
Structural integration	0	0	0	0	0	0	0	3	3	0	0	
Total (12)	0	1	0	0	1	1	0	1	3	4	0	1

b. Indirect object relative clause (right-branching)

The boy disliked the teacher who the girl gave the book to *e*.

New discourse referent	0	1	1	0	1	0	0	1	1	0	1	0
Structural integration	0	0	0	0	0	0	0	0	0	0	0	3
Total (9)	0	1	1	0	1	0	0	1	1	0	1	3

(11) a. Object of preposition relative clause (right-branching)

The boy disliked the teacher who the girl talked about *e*.

New discourse referent	0	1	1	0	1	0	0	1	1	0	0	0
Structural integration	0	0	0	0	0	0	0	0	0	2	0	2
Total (7)	0	1	1	0	1	0	0	1	1	2	0	2

b. Object of preposition relative clause (center-embedding)

The boy who the girl talked about *e* disliked the teacher.

New discourse referent	0	1	0	0	1	1	0	1	0	1	0	1
Structural integration	0	0	0	0	0	0	2	2	0	0	0	0
Total (9)	0	1	0	0	1	1	2	3	0	1	0	1

(12) a. Genitive relative clause (right-branching)

The boy disliked the girl whose mother is a teacher.

New discourse referent	0	1	1	0	1	0	1	1	0	1	0	1
Structural integration	0	0	0	0	0	0	0	0	0	0	0	0
Total (6)	0	1	1	0	1	0	1	1	0	1	0	1

b. Genitive relative clause (center-embedding)

The boy whose mother is a teacher disliked the teacher.

New discourse referent	0	1	0	1	1	0	1	0	0	1	0	1
Structural integration	0	0	0	0	0	0	0	3	0	0	0	0
Total (8)	0	1	0	1	1	0	1	3	0	1	0	1

(13) a. Relative clause with subject of comparison (right-branching)

The boy disliked the teacher who is shorter than the girl.

New discourse referent	0	1	1	0	1	0	1	0	0	0	1
Structural integration	0	0	0	0	0	0	0	0	0	0	0
Total (5)	0	1	1	0	1	0	1	0	0	0	1

b. Relative clause with subject of comparison (center-embedding)

The boy who is shorter than the girl disliked the teacher.

New discourse referent	0	1	0	1	0	0	0	1	1	0	1
Structural integration	0	0	0	0	0	0	0	0	2	0	0
Total (7)	0	1	0	1	0	0	0	1	3	0	1

(14) a. Relative clause with object of comparison (right-branching)

The boy disliked the teacher who the girl is shorter than *e*.

New discourse referent	0	1	1	0	1	0	0	1	1	0	0
Structural integration	0	0	0	0	0	0	0	0	0	0	2
Total (7)	0	1	1	0	1	0	0	1	1	0	2

b. Relative clause with object of comparison (center-embedding)

The boy who the girl is shorter than *e* disliked the teacher.

New discourse referent	0	1	0	0	1	1	0	0	1	0	1
Structural integration	0	0	0	0	0	0	0	2	2	0	1
Total (9)	0	1	0	0	1	1	0	2	3	0	1

To make a clear comparison across different types of relative clauses, Table 2 lists the total energy consumption for each type of relative clause occurring in right-branching and center-embedded positions.

Table 2. Total number of energy units consumed for each type of RC

	Right-branching (O)	Center-embedding (S)
Subject	5	7
Direct Object	7	9
Indirect Object	9	12
Object of Preposition	7	9
Genitive (whose)	6	8
Subject of Comparison	5	7
Object of Comparison	7	9

Table 2 shows that for each type of relative clause, center-embedded relative clauses consume more energy than right-branching relative clauses. The fact that center-embedded relative clauses consume more energy was further illustrated by Gibson, who used DLT calculations to show the energy consumption of doubly-embedded relative clauses. An example of a doubly-embedded relative clause is given below.

	The boy who the girl who the teacher saw <i>e</i> liked <i>e</i> visited the zoo.												
New discourse referent	0	1	0	0	1	0	0	1	1	1	1	0	1
Structural Integration	0	0	0	0	0	0	0	0	2	6	4	0	0
Total (19)	0	1	0	0	1	0	0	1	3	7	5	0	1

This example clearly shows that doubly-embedded object relative clauses are much more difficult than singly-embedded object relative clauses since the total energy consumption rises to 19. If we look at right-branching relative clauses in Table 2, the order of difficulty is:

Subj = SCOMP > GEN > DO = OPREP = OCOMP > IO (“>” meaning “easier”).

For center-embedding relative clauses, the order of difficulty is:

Subj = SCOMP > GEN > DO = OPREP = OCOMP > IO (“>” meaning “easier”)

The order of difficulty for both right-branching positions and center-embedded positions is exactly the same. However, this does not imply that a subject relative clause in a right-branching position is of the same difficulty as a subject relative clause in a center-embedded position. In fact, based on the energy cost in Table 2, subject relative clauses in the right-branching position are easier than those in the center-embedded position.

2. Problems with previous studies

Studies looking at relative clause acquisition in first and second languages have mostly used experimental procedures such as sentence-combining tasks (e.g., Gass 1979, 1980, Ioup 1983), grammaticality judgment tasks (Ioup & Kruse 1977, Eckman, Bell & Nelson 1988, Hamilton 1994, Izumi 2003), sentence completion tasks (Iwami 1991) and comprehension tasks (Cook 1973, Tavakolian 1981, Roth 1984, Flanigan 1995). In sentence-combining tasks, participants are given several sets of two

sentences and are instructed to combine the sentences using relative clauses. In grammaticality judgment tasks, participants are asked to judge whether the sentence stimuli they read are grammatical or not. In sentence completion tasks, participants either fill in blanks with correct relative pronouns or choose a response that has the correct relative clause usage. In word order tasks, participants are simply asked to choose an answer with correct use of a relative clause structure. Some of the studies used one kind of measure to probe learners' production (Ioup & Kruse 1977, Schumann 1980, Tavakolian 1981, Ioup 1983, Eckman, Bell & Nelson 1988) while other studies used a composite of different measures (Prideaux & Baker 1986, Doughty 1991, Ozeki & Shirai 2007).

Taken together, these different methods specifically direct participants' attention toward relative clause construction and the results are used as evidence to support either the NPAH or the PDH. For example, Brown (1971), Tavakolian (1981), Romaine (1984), Prideaux & Baker (1986), Eckman, Bell & Nelson (1988), and Yip & Matthews (1991) supported the NPAH. On the other hand, Cook (1973), Ioup & Kruse (1977) Schumann (1980), and Flanigan (1995) supported the PDH. Additionally, some studies failed to support either theory (e.g. Ioup 1983) while others supported both (e.g., some experiments in Prideaux & Baker 1986).

Regarding subjects that were recruited in these studies, both L1 and L2 speakers were investigated, including adults (Brown 1971, Ioup & Kruse 1977, Gass 1980, 1982, Pavesti 1986, Prideaux & Baker 1986, Eckman, Bell & Nelson 1988) and children (Tavakolian 1981, Romaine 1984, Roth 1984).

Even though previous studies have used a wide variety of tasks, it should be noted that the results from these measures are still subject to question since we do not know whether the same conclusion can be drawn when the subjects' attention is not geared toward relative clauses. At this juncture, natural data will serve as an ideal measure to examine the acquisition of relative clauses. Of all the previous studies, Yip & Matthews (2007) was one of the very few which examined longitudinal natural data. Diaries of three Cantonese-English bilingual children (the age ranged from 1;00 to 6;00) were traced to investigate the emergence of relative clauses in both languages over several years. They found that Cantonese object relative clauses emerged earlier than Cantonese subject relative clauses. However, the same pattern was also found for English. That is, these three bilingual children also produced English object relative clauses earlier than English subject relative clauses. According to Yip and Matthews, these results pose challenges to the NPAH. Even though Yip and Matthews' study examined natural data, their results should be taken with a grain of salt for several reasons. First of all, the subject pool was too small. Only three children's diaries were examined and not much of their language background was revealed. In addition, prior

studies have found that English native speakers find English subject relative clauses to be easier than English object relative clauses. However, the fact that Yip and Matthews' study found the opposite pattern cast some doubt on the results of their study. It is possible that their dominant language, Cantonese, influenced their acquisition of English, leading to the earlier emergence of the more difficult English object relative clauses. Third, since the three children were too young to keep diaries, the diaries were actually kept by their parents. It is possible that each type of relative clause emerged earlier but was simply not recorded.

3. Experimental procedure

Based on the above discussion and the limitations of previous studies, the purpose of the current study was twofold. First, it aimed to examine the predictions of three major hypotheses, i.e., the NPAH, the PDH and the DLT, concerning the order of difficulty of relative clauses production among Mandarin learners of English. Note that different theories have made different predictions regarding different types of relative clauses and it is worth scrutinizing their predictions. For NPAH, the 2007 version does not tease apart indirect object relative clauses and object of preposition relative clauses. It would be of interest to empirically test whether there is any difference in the production of these two types of relative clause.

In order to examine second language learners' natural language production, English compositions produced by Mandarin EFL learners were collected and examined. Second, given that relative clauses are more complex and proficiency plays a major role in second language learning, the current study also wanted to examine developmental growth of different types of relative clauses in written production among Mandarin learners with different levels of proficiency. Since most Mandarin learners of English do not start to write English compositions until either the second or the third year of senior high school, the earliest English compositions collected were from sophomore students in senior high school. In addition to high school sophomore students, the current study also collected compositions from the four other groups of Mandarin learners: senior students in senior high schools, first-year college non-English majors, first-year college English majors and second-year English majors. Since English and non-English majors do not necessarily represent clear-cut high versus intermediate English levels, the current study only included non-English majors whose English scores on the college entrance exam were between 70 and 85. For English majors, their English scores on the entrance exam were above 88. Furthermore, in order to avoid sampling bias, the compositions were collected from three different public senior high schools and three different public and private universities in Taiwan. For high school

sophomores and seniors and college non-English majors, there were approximately the same number of male and female students. However, there were more female students in the two groups of college English majors.

The compositions were scrutinized for their uses of different types of relative clause. Since the current study aimed to quantify the production of relative clauses in compositions, a similar total number of words across all compositions in each group was vital. For high school sophomore students, a total of two hundred and twenty-one compositions were collected, a total of 40,151 words. For high school senior students, a total of two hundred and five compositions were collected, a total of 40,193 words. For college non-English majors, a total of one hundred and fifty compositions were collected, a total of 40,176 words. For freshman English majors, a total of one hundred and two compositions were collected, a total of 40,168 words. For sophomore English majors, a total of eighty-seven compositions were collected, a total of 40,142 words. Finally, writing of native English speakers was taken from the Yahoo US website and these articles consisted of a total of 40,188 words. The articles by native English speakers were included as a baseline in the investigation of whether there was a linear trend of growth in the production of relative clauses when students' English proficiency increased.

Different types of relative clauses were identified and counted in students' compositions, including subject relative clauses (Subj), direct object relative clauses (DO), indirect object relative clauses (IO), object of preposition relative clauses (OPREP or Oblique), genitive relative clauses (Gen), and finally subject and object comparison relative clauses (SCOMP and OCOMP). Furthermore, unlike previous studies which only focused on the relative pronoun "who", this study included all relevant relative pronouns since they all indicate relative clause construction. For example, for subject relative clauses, relative clauses containing relative pronouns such as "who", "which" and "that", were identified. For direct object relative clauses, the following relative pronouns were identified — "who", "which", "that" and "whom". For genitive relative clauses, the relative pronoun "whose" was identified.

4. Results

4.1 Order of difficulty

Table 3 presents the tokens of different types of relative clauses occurring in right-branching and center-embedded positions across English native speakers (NS) and Mandarin learners of English (NNS). Note that for each cell in NNS, the number represents the combined results across five proficiency groups. According to the total number of tokens between right-branching and center-embedded

relatives, Table 3 reveals that there were many more right-branching tokens than center-embedded ones in both NNS and NS groups, which reached significance in statistics (NNS: $\chi^2(1) = 176.89$, $p < .01$; NS: $\chi^2(1) = 44.354$, $p < .01$). In addition, except for those cells containing zero tokens, all sub-categories also reached significance in the NNS group when comparing the difference between right-branching and center-embedded ones (NNS: subject relatives: $\chi^2(1) = 95.235$, $p < .01$; object relatives: $\chi^2(1) = 32.19$, $p < .01$; indirect object relatives: $\chi^2(1) = 6.4$, $p < .05$; object of preposition relatives: $\chi^2(1) = 30.311$, $p < .01$) For NS groups, most comparisons also reached significance except for some pairs (NS: subject relatives: $\chi^2(1) = 23.379$, $p < .01$; object relatives: $\chi^2(1) = 7.364$, $p < .01$; object of preposition relatives: $\chi^2(1) = 15.207$, $p < .01$; indirect object relatives, genitive and subject and object of comparisons: $p > .05$). In general, both NNS and NS groups support the claim that right-branching relatives are easier than center-embedded ones since there were more tokens of right-branching relative clauses in the corpus across different proficiencies.

Table 3. Tokens of relative clause types

Speakers	Right-branching (O)		Center-embedded (S)	
	NNS (5 groups)	NS	NNS (5 groups)	NS
Subject (Subj)	189	73	41	22
Direct Object (DO)	63	31	16	13
Indirect Object (IO)	9	12	1	8
Object of Preposition (OPREP or Oblique)	52	25	9	4
Genitive (Gen)	12	7	0	2
Subject of comparison (SCOMP)	5	3	0	1
Object of comparison (OCOMP)	3	3	0	1
Total	333	144	67	51

In addition to performing a basic chi-square analysis, a generalized linear regression analysis with a Poisson distribution was also conducted. There were main effects for three independent variables (Right vs. Center RCs: Wald $\chi^2(1) = 184.574$, $p < .01$; RC type: Wald $\chi^2(1) = 523.898$, $p < .01$; Subject Groups: Wald $\chi^2(1) = 174.65$, $p < .01$). The statistical results reveal again that right-branching relative clauses are easier than center-embedded ones. Different types of relative clauses also pose different levels of difficulty for subjects. Since there was a main effect of relative

clause type, pairwise comparisons were also performed. Basically, all pairwise comparisons reached statistical significance ($p < .05$), except for some pairs (i.e., Genitive vs. IO; SCOMP vs. OCOMP). Finally, there were also significant differences among different groups of subjects. Pairwise comparisons for different pairs of groups of subjects also reached statistical significance ($p < .05$), except for the pair between high school sophomore and senior students.

For native English speakers, the tokens of the current study conform more to the predictions of the NPAH and PDH, but less to predictions based on the DLT. For NNS, Table 3 also reveals the number of tokens for each type of relative clause.

For right-branching relative clauses, the order of difficulty is:

Subj > DO > OPREP (Oblique) > Gen > IO > SCOMP > OCOMP

For center-embedded relative clauses, the order of difficulty is:

Subj > DO > OPREP (Oblique) > IO > Gen = SCOMP = OCOMP

The order of difficulty is similar between right-branching relative clauses and center-embedded relative clauses. The top three kinds of relative clauses that Mandarin learners produce are the subject relative clause, the object relative clause and the object of preposition relative clause.

To compare the results of the current study with predictions based on each theory, here are the predictions of the DLT, NPAH, and PDH again.

(a) Dependency Locality Theory

Right-branching relative clauses

Subj = SCOMP > GEN > DO = OPREP (Oblique) = OCOMP > IO

Center-embedding relative clauses

Subj = SCOMP > GEN > DO = OPREP (Oblique) = OCOMP > IO

(b) Perceptual Difficulty Hypothesis

OS > OO > SS > SO.

(c) Noun phrase accessibility hierarchy (1977 Version)

Subj > DO > IO > Oblique > Gen > OCOMP

(d) Noun phrase accessibility hierarchy (2007 Version)

Subj > DO > other object > Genitive/possessor

In general the results of the current study conform entirely to the predictions of PDH. This is probably because the PDH is the only theory that makes predictions regarding subject and object relative clauses occurring at matrix subject and object positions. It does not make detailed predictions regarding other different types of relative clauses such as indirect object relative clause or genitive relative clauses as the NPAH and DLT do.

Regarding the NPAH 1977 version, the results of the current study conform largely to its predictions. For right-branching relative clauses, Mandarin learners' production of relative clauses was largely consistent with the NPAH except for the indirect object relative clauses and object of preposition relative clauses. Table 3 clearly shows that there are many more tokens of objects of preposition than for indirect objects. For center-embedding relative clauses, the results were similar to right-branching ones except that there were zero tokens for genitive and comparison ones across different groups of subjects. This can be taken as another piece of evidence that center-embedded relative clauses are more difficult than right-branching relative clauses. Thus, when using center-embedded relative clauses, Mandarin learners did not have additional resources available in their cognitive system to generate more difficult types of relative clauses.

The NPAH 2007 version is different from the 1977 version in that, first, it merges indirect object relative clauses and object of preposition relative clauses into one single category, labelled "other object". Second, the 2007 version does not have objects of comparison relative clauses. The results of the current study, however, called for a separation of these types of relative clauses. For the right-branching position, object of preposition relative clauses are produced almost six times more often than indirect object relative clauses by the non-native English speakers. For the center-embedded position, object of preposition relative clauses are nine times more common among non-native English speakers than indirect object relative clauses. It is therefore obvious that object of preposition relative clauses are easier to produce than indirect object relative clauses. In addition, there is more production of genitive relative clauses than subject and object relative clauses. Thus a distinction among these types of relative clauses should be added as well.

Since DLT employs detailed calculations for energy cost, it can be used to predict the order of difficulty for all these types of relative clauses. In general, DLT is also correct in predicting that subject relative clauses are easier than object relative clauses and in predicting that center-embedded relative clauses are more difficult than right-branching ones. However, when we examine the DLT more closely, we see that there is no difference between OO and SS, which,

according to the current findings, are not as predicted. Despite this, the DLT is the only theory that correctly predicts that object of preposition relative clauses are easier than indirect object relative clauses, as the results indicate that there are far more tokens relating to oblique relative clauses than to indirect object relative clauses. Finally, with respect to comparison and genitive relative clauses, the DLT incorrectly predicts the difficulty of relative clauses among Mandarin learners of English. It predicts that comparison and genitive relative clauses are a lot easier than other types of relative clauses such as direct object, indirect object and oblique relative clauses, and yet they turn out to be quite difficult for Mandarin learners of English.

Figure 1 and Figure 2 present the production of different types of relative clauses occurring in the right-branching position (Figure 1) and center-embedded position (Figure 2) among six groups of subjects. What is interesting about these two figures is that all five different groups of learners show similar patterns of production with respect to different types of relative clause. Both figures show a bump in the middle of the graph, which indicates more production of object of preposition relative clauses across the five groups of learners than indirect object relatives, genitive relatives and comparison relatives. All in all, for the right-branching position, all five lines in Figure 1 display highly similar patterns. Regarding the center-embedded position, except for high school sophomores, the rest of the four lines show similar patterns.

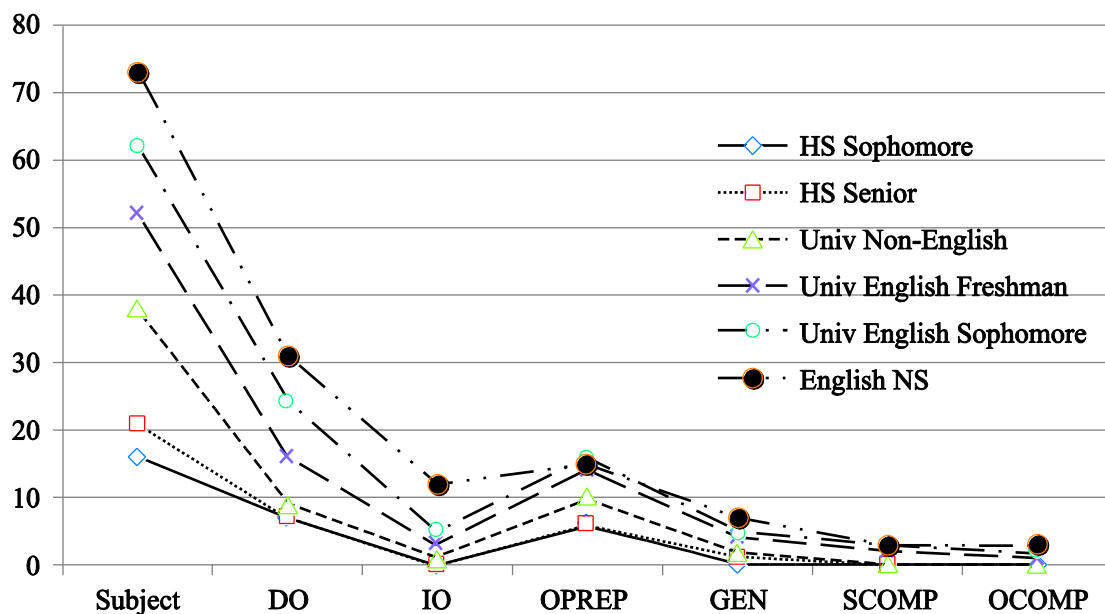


Figure 1. Relative clause types occurring at right-branching position

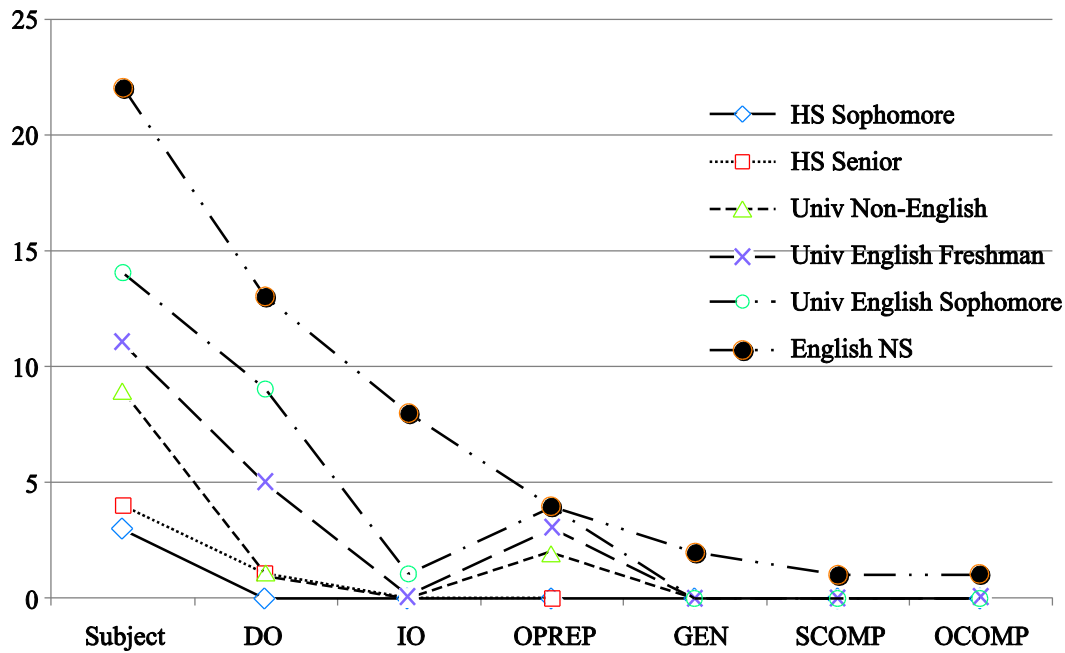


Figure 2. Relative clause types occurring at center-embedded position

4.2 Growth of relative clauses among five groups of NNS subjects

Since relative clauses are more difficult than syntactic structures such as simple subject-verb-object constructions, it would be of interest for researchers to observe the use of relative clauses among Mandarin learners of different proficiency levels to see whether their production of relative clauses grows over time. Figure 3 shows the use of different relative pronouns across six groups in subject relative clauses occurring in the sentential subject position. The solid line, representing the total number of different relative pronouns, clearly reveals that there is linear growth regarding subject relative clauses as Mandarin students' proficiency increases. As students became more proficient in English, there were more tokens related to subject relative clauses produced in the right-branching relative clauses. In addition, there was a reliable difference in the production of subject relative clauses occurring in the right-branching position among the six groups (Wald $\chi^2(5) = 52.785$, $p < .01$). Pairwise comparisons revealed significant differences among most pairs ($p < .01$), except for these following pairs (English Freshmen vs. English sophomores, $p = .349$; native English speakers vs. English sophomores: $p = .344$; high school sophomores vs. high school seniors: $p = .411$).

Furthermore, in terms of relative pronouns, more use of "which" than "who" and "that" was found in high school sophomores, seniors and non-English college majors. But the situation is reversed for English majors in college. They used "who" more

than “which” and “that”. Note that for native English speakers, there were more uses of “that” than of other kinds of relative pronouns in the corpus.

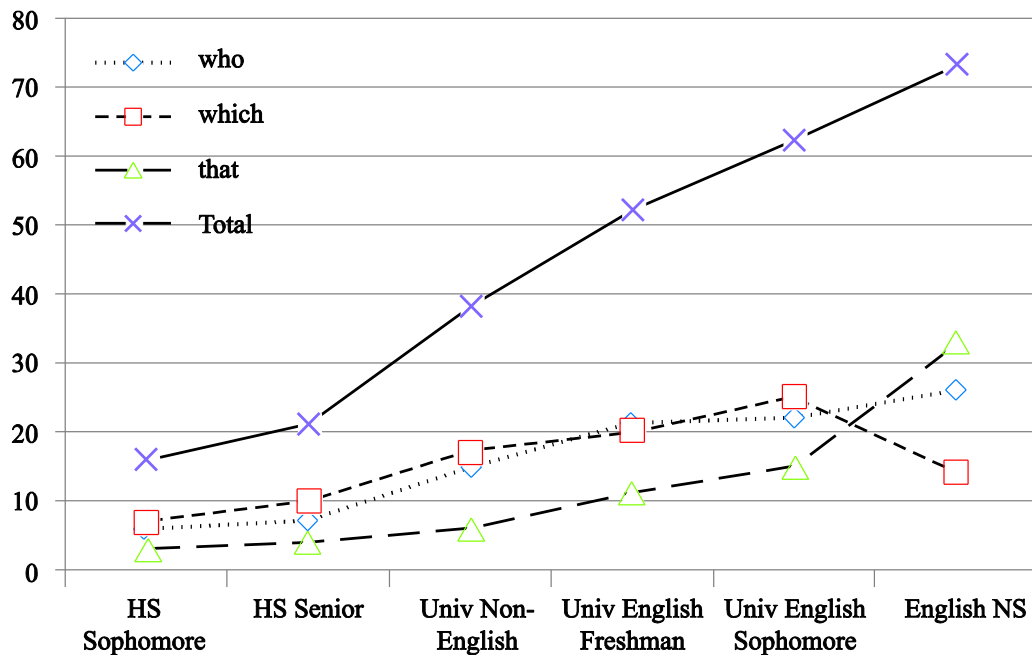


Figure 3. Right-branching subject relative clauses

Figure 4 shows subject relative clauses occurring in the center-embedded position across the six groups of subjects. There was a reliable difference in the production of subject relative clauses occurring in the center-embedded position among the six groups (Wald $\chi^2(5) = 19.654, p < .01$). Pairwise comparisons revealed significant differences in many pairs (English freshmen vs. high school sophomores; English freshmen vs. native English speakers; English freshmen vs. high school seniors; native English speakers vs. high school seniors; native English speakers vs. high school sophomores; native English speakers vs. non-English college majors; English sophomores vs. high school seniors; English sophomores vs. high school sophomores, $p < .05$).

For high school students, either in the second or the third year, their production of relative clauses in the center-embedded position was close to zero. This is not surprising since embedding a clause into another clause is more difficult than simply inserting a relative clause at the end of a sentence. Despite this, linear growth of using subject relative clauses in the center-embedded position can also be observed. However, compared with the total number of tokens in the right-branching position, the linear line is much less steep.

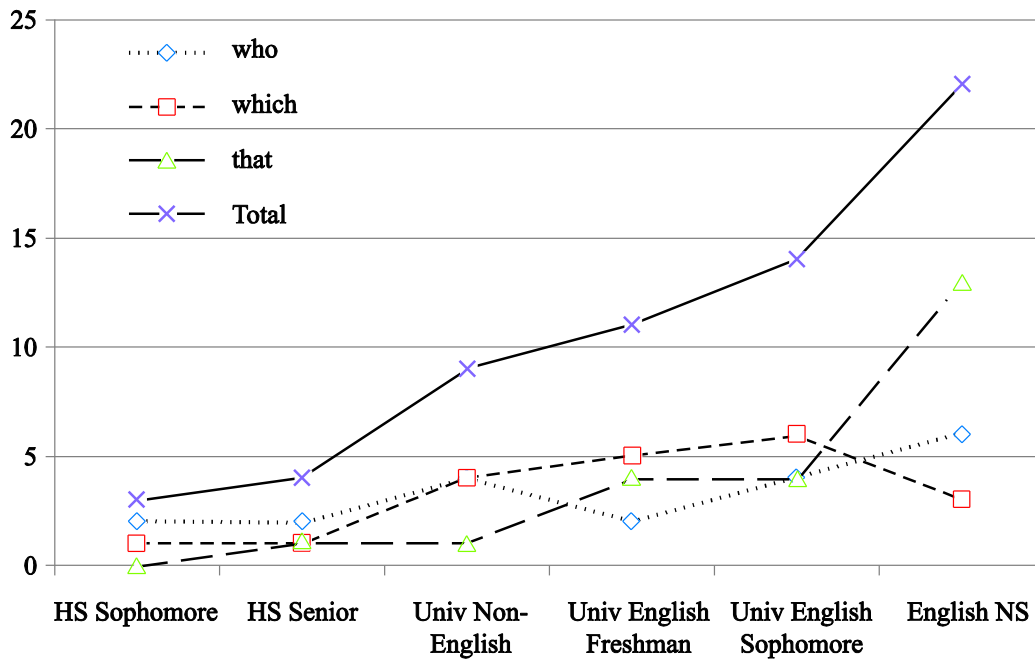


Figure 4. Center-embedded subject relative clauses

Figure 5 illustrates direct object relative clauses occurring in the right-branching position across six subject groups. Note that the word order for the direct object relative is OSV, which is not the typical SVO word order and therefore there are fewer tokens of direct object relative clauses produced, even in the right-branching position. Even though there were more than 40,000 words produced by each group, there were fewer than 10 tokens of direct object relative clauses produced by high school sophomores, high school seniors and non-English college majors. Statistical analysis revealed a reliable difference among the six subject groups (Wald $\chi^2(5) = 28.12$, $p < .01$). Pairwise comparisons revealed reliable differences in most of the pairs ($p < .05$), except in the following pairs (English freshmen vs. English sophomores; English freshmen vs. non-English college majors; native English speakers vs. English sophomores; high school seniors vs. high school sophomores, $p > .05$).

With respect to the use of relative pronouns, there were also more tokens of “which” than of other types of relative pronoun. Interestingly, even though “whom” is taught in school as the correct relative pronoun for direct object relative clauses, there was zero production of “whom” by high school sophomores, high school seniors and non-English majors in university. This shows that when the Mandarin learners were producing the more difficult object relative clauses, they tended to use “who” to replace “whom” in writing. For native English speakers, more tokens of “that” were found.

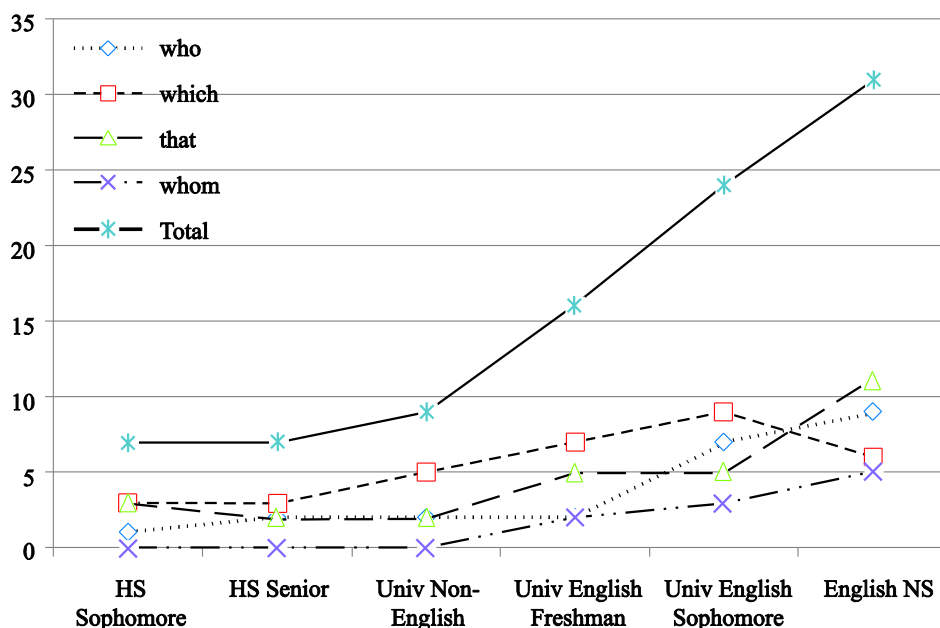


Figure 5. Right-branching direct object relative clauses

Figure 6 shows direct object relative clauses occurring in the center-embedded position. Since both center-embedded position and direct object relatives are more complex for learners, such double layers of difficulty make it hard for Mandarin learners. For high school sophomores, high school seniors and non-English majors in university, the production of direct object relatives was close to zero. For both groups of English majors in college, there were also fewer than ten tokens. Overall, there was a reliable difference across the six groups of subjects ($p < .05$). Pairwise comparisons reveal a significant difference in most pairs ($p < .05$), except in the following pairs (English freshmen vs. English sophomores; native English speakers vs. English sophomores; high school seniors vs. high school sophomores, $p > .05$).

For indirect object relative clauses, object of preposition relative clauses, genitive relative clauses and comparison relative clauses, since there were a lot fewer tokens of production across the six groups of subjects, the relative clauses occurring in right-branching and center-embedded positions are presented together. Figure 7 illustrates the tokens of indirect object relative clauses occurring in both positions across the six groups. The figure clearly shows linear growth of indirect object relative clauses occurring in both the right-branching and center-embedded position. There is a reliable difference in the statistics across the six groups ($p > .05$) for IO to occur in both positions (right-branching: $p < .05$; center-embedded: $p = .05$). For the right-branching position, pairwise comparisons revealed reliable differences in most pairs ($p < .05$), except for the following pairs (English freshmen vs. English sophomores; non-English college majors vs. English freshmen; high school seniors vs.

high school sophomores, $p > .05$). For the center-embedded position, pairwise comparisons also revealed reliable differences in some pairs ($p < .05$). Some other pairs, however, did not reach significance (English freshmen vs. English sophomores; English freshmen vs. high school sophomores; English freshmen vs. non-English majors; English sophomores vs. high school seniors; English sophomores vs. high school sophomores; English sophomores vs. non-English college majors; non-English college majors vs. high school sophomores, $p > .05$).

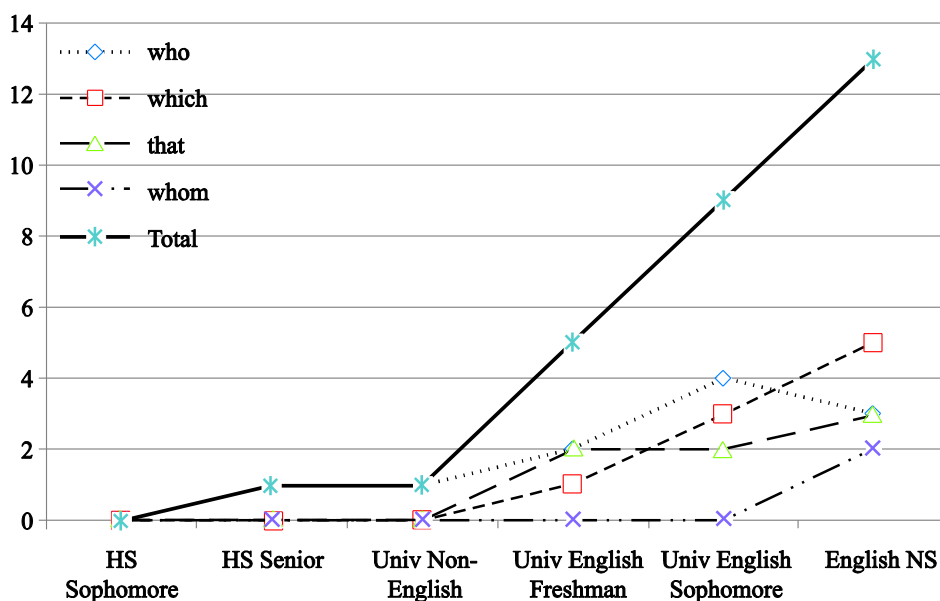


Figure 6. Center-embedded direct object relative clauses

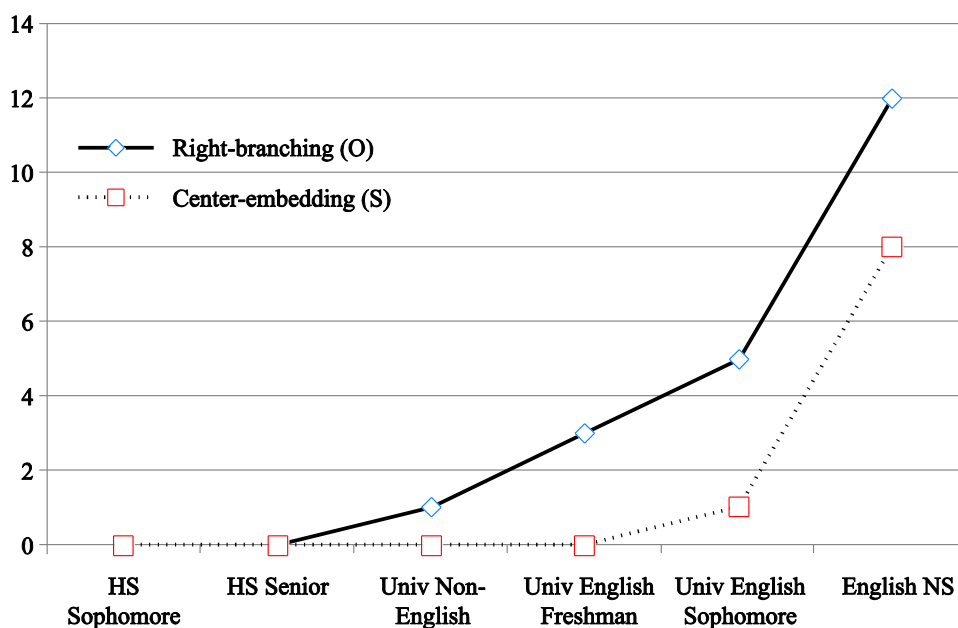


Figure 7. Indirect object relative clauses

Figure 8 shows object of preposition relative clauses occurring in the right-branching and center-embedded positions. Unlike indirect object relative clauses, there were more tokens of this type of relative clause occurring in the right-branching position and linear growth could also be observed. However, no statistically reliable differences were found (Wald $\chi^2(5) = 8.502, p = .131$). With respect to object of preposition relative clauses occurring in the center-embedded position, there were far fewer tokens in the students' production. The figure also shows linear growth in using this type of relative clause as students become more proficient but there is also no reliable difference across the six groups (Wald $\chi^2(5) = 0.82, p = .845$). Even though there are not many tokens of object of preposition relative clauses occurring in the center-embedded position, compared with indirect relative clauses, there are still more tokens of object of preposition relative clauses than tokens of indirect object relative clauses.

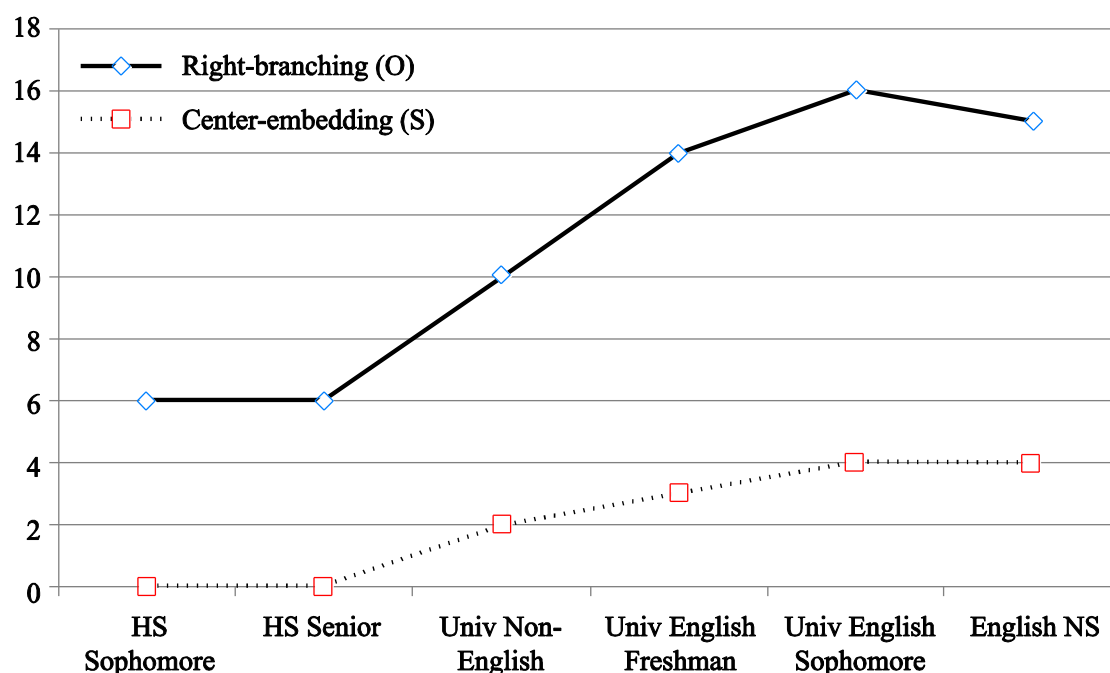


Figure 8. Object of preposition relative clauses

Figure 9 illustrates the tokens of genitive relative clauses occurring in the center-embedded and right-branching positions across the six groups of subjects. For the right-branching position, although a linear trend regarding the use of more genitive relative clauses can be observed, no reliable difference was evident across the six groups ($p > .05$). For center-embedded relative clauses, there was also no reliable difference ($p > .05$).

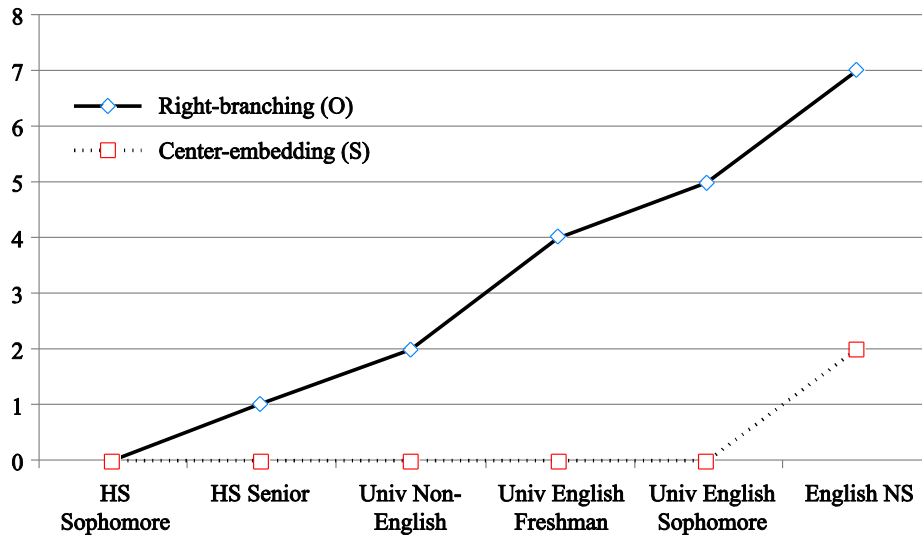


Figure 9. Genitive relative clauses

Figure 10 and Figure 11 illustrate tokens of subject of comparison relative clauses and object of comparison relative clauses occurring in the right-branching and center-embedded positions across the six groups of subjects. There were only a few tokens for each type of comparison relative clause and both types occur in the right-branching position. In addition, only university English majors and native English speakers produced this type of relative clause. No reliable differences were found in either Figure 10 or Figure 11 ($p > .05$). For center-embedded ones, there were zero tokens for each type of comparison relative clause, apart from those produced by native English speakers.

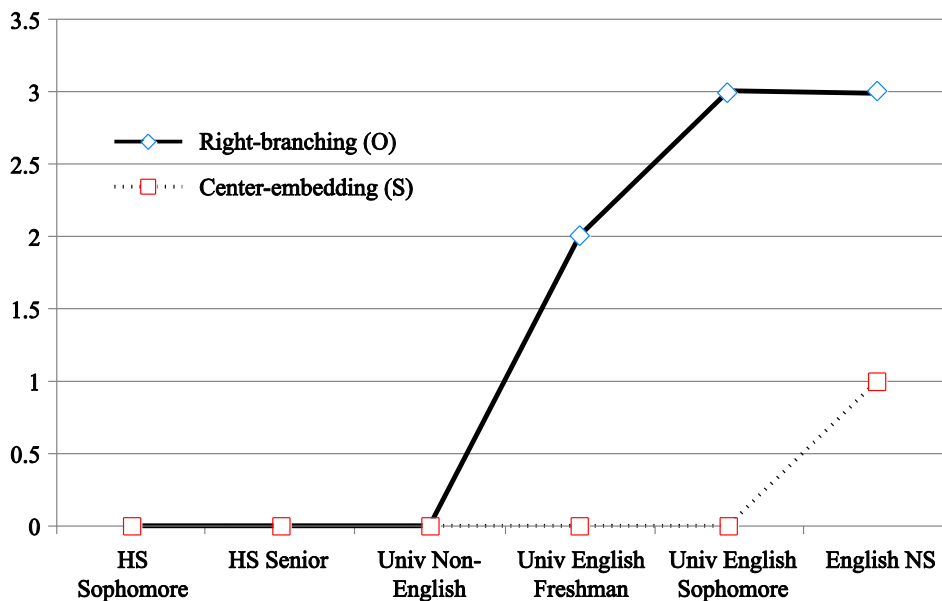


Figure 10. Subject of comparison

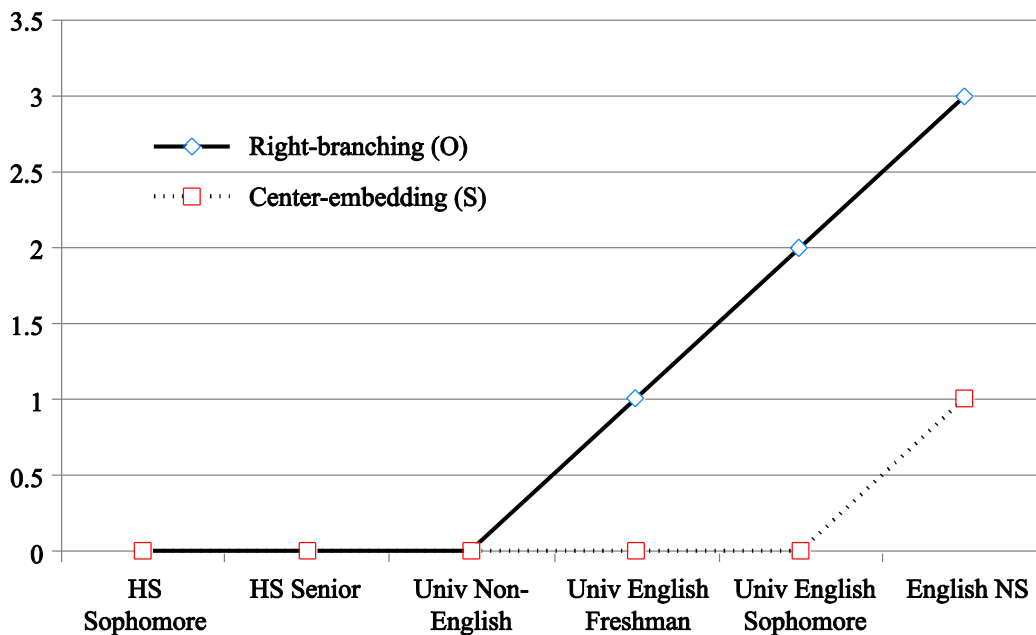


Figure 11. Object of comparison

5. General discussion

The purpose of the current study was, first of all, to examine the predictions of different theories proposed to explain the order of difficulty of different types of relative clauses and, second, to observe developmental growth in using relative clauses among Mandarin learners of different proficiency levels by examining their English compositions. This measure was employed to bridge a gap. Previous studies have mostly used comprehension tasks and sentence-combining tasks, which specifically direct subjects' attention toward relative clause constructions. In order to prevent unwanted attention on the use of relative clauses, this current study employed a large-scale corpus study to investigate students' production of English relative clauses in their English compositions.

The results of the current study reveal that the order of difficulty shown in production of different types of relative clauses is similar for both right-branching and center-embedded positions. Basically, there were more tokens of subject relative clauses than other types of relative clauses across the different groups of subjects. English subject relative clauses have a SVO word order, which is also the canonical word order in Mandarin. But note that Mandarin object relative clauses also have the canonical SVO word order. That Mandarin subjects did not produce more English object relative clauses but produced more English subject relative clauses offers another piece of evidence that frequency plays a major role in language comprehension and production. Note that these results come from a large-scale composition pool from a wide range of learners at

different levels of proficiency. The PDH, which makes predictions that are not as fine-grained as those of the other two theories, only offers predictions regarding subject and object relative clauses occurring in the right-branching and center-embedded positions. Despite its simplicity, the results of the current study fully support its predictions.

The NPAH and the DLT, on the other hand, have offered predictions regarding the order of difficulty for more types of relative clauses. But they have their own strengths and weaknesses. DLT was also the only theory that made correct predictions with respect to the difficulty between indirect object relative clauses and object of preposition relative clauses (DLT prediction: OPREP > IO). However, DLT was incorrect with respect to genitive relative clauses and subject of comparison relative clauses (DLT prediction: Subj = SCOMP > GEN > DO). Regarding the NPAH 1977 version, it correctly predicted the order of difficulty for genitive and object of comparison but it failed to correctly predict the order of difficulty for indirect object relative clauses and object of preposition relative clauses. The NPAH 2007 is less fine-grained than the NPAH 1977 version. First of all, indirect object and object of preposition were merged into one single category called “other object”. Second, comparison relative clauses were left out. The results of the current study clearly show that production of indirect object relative clauses and object of preposition relative clauses are not the same. What is worth noting is that this was true across six groups of learners. The results of the current study suggest that there should be a clear distinction of difficulty made between these two types of relative clauses. Furthermore, a distinction between genitive relative clauses and subject/object comparison relative clauses should also be made.

Overall, the results of the current study strongly suggest that each theory takes into account several important points: first of all, the results show that different levels of difficulty are associated with right-branching and center-embedded relative clauses. Thus, where a relative clause occurs should be taken into consideration in every theory. Second, a more scientific explanation of the order of difficulty, such as in the DLT, is called for. Even though the DLT fails to predict the difficulty of some relative clauses, it is still a very powerful theory in terms of determining the processing and acquisition of relative clauses. Third, no theory has yet taken into account difficulties associated with different relative pronouns. The present study, nevertheless, reveals that different relative pronouns pose different levels of difficulty to Mandarin learners.

Finally, regarding developmental growth of relative clauses among Mandarin learners, the current study shows linear growth in the production of relative clauses as learners' proficiency increases. This is especially clear when relative clauses occur in the right-branching position. For subject relative clauses occurring in the right-branching position, Mandarin learners initially produced fewer than 20 tokens. But

production quickly more than doubled for non-English college majors. This shows that when people are more proficient in English, they are more capable of producing more complex syntactic structures. Linear growth in the production of relative clauses is less clear when they occur in the center-embedded position. This is due to the fact that it is already the more difficult structure. For second language learners, inserting a relative clause into a sentence interrupts the flow of thought, making it even more cognitively demanding. This further explains why there was zero production of other types of relative clauses, which are even more difficult.

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中文母語者在英文關係子句之習得發展

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在闡釋關係子句的處理和習得之困難處時，先前的研究幾乎都著重於兩個重要的理論：『名詞片語可存取階層』及『感知困難假說』。近幾年來，『依附區域理論』提出針對句子的每一個字詞做出能量單位的運算法則。此理論在心裡語言學領域也已獲得廣大的注意和研究支持。本研究旨在看中文母語者在英文作文裡關係子句的使用多寡，用以檢視三個理論。中文母語者寫的英文作文並不像傳統其他研究一般要求受試者判斷文法正確性或是結合句子使用。後兩種方法都直接的將受試者的注意力引導至關係子句上。但卻不知在自然不受引導的狀態下，外語學習者關係子句的產生是否與先前研究結果一致。此外，在外語研究上，因語言程度佔了一個重要的位置，故本研究收集了五種程度的學生英文作文：高二學生，高三學生，大學裡非英外文系學生，英外文系大一學生，與英外文系大二學生。每一個族群的學生作文皆包含四萬字左右。本研究細查學生各種關係子句使用狀況，並計算各種關係子句的總數。研究結果發現不同英文程度的確會產生數目多寡不一的關係子句。隨著英文程度提升，學生在作文中也有顯著較多的關係子句產生。最後，本研究也發現每個理論皆有其獨到貢獻處，可用來解釋不同程度學生的關係子句產出狀況。

關鍵詞：關係子句、心理語言學、語句產生