Phonologically Motivated Word Order Movement:

Evidence from Chinese Compounds*

San Duanmu

August 1997

Abstract

Chinese compounds exhibit word order variations that have so far not been well understood. In this article I propose that the word order variation is motivated by metrical requirements. I also propose that the mechanism for word movement is Nonhead Fronting, an operation that is similar to XP movement by adjunction in syntax.

1. Introduction

Compounds in Chinese have several word order variations. This can be seen in the examples in (1).[1]

(1)	Phrase	Compound
a.	[[V O] N]	[V O N]
	qie cai de dao	qie cai dao
	cut vegetable DE knife	cut vegetable knife
	'knife that cuts vegetables'	'vegetable-cutting knife'
b.	[[V O] N]	[O V N]
	jiagong luobo de dao	luobo jiagong dao
	process turnip DE knife	turnip process knife
	'knife that processes turnip'	'turnip-processing knife'
c.	[[V [M O]] N]	[M V O N]
	xue pingguo pi de dao	pingguo xue pi dao
	peel apple skin DE knife	apple peel skin knife
	'knife that peels apple skin'	'apple skin-peeling knife'

The column on the left shows nominal phrases with a relative clause that contains a verb (V) and an object (O) (the particle 'de' can be considered a relativizer, the equivalent of 'that'). The column on the right shows the

corresponding compounds; let us call them [V-O N] compounds. In the phrase column the word order is constant: V precedes O in the relative clause, and the relative clause precedes the head noun (N). In the compound column the word order is variable: in (1a) it is [V O N], in (1b) it is [O V N], and in (1c) it is [M V O N] (where M is the modifier of O). The word order is not free. Rather, it is determined by the syllable count of the component words. For example, when V and O are both monosyllabic, [V O N] is the only possible word order, as seen in (1a). When V and O are both disyllabic, [O V N] is the only possible word order, as seen in (1b). Judgments on such word orders are quite sharp, but the issue has not been adequately addressed in published literature.

The data in (1) raises a number of questions. For example, why does the word order vary in Chinese [V-O N] compounds? Why is the word order constant in the English counterparts? What is the full range of patterns in Chinese [V-O N] compounds? What is the internal bracketing of the compounds? Are there word order variations in other Chinese compounds? Are there word order variations in English compounds? The main goal of this article is to provide answers to these questions. I propose that all Chinese [V-O N] compounds have an underlying word order, and that surface changes from it are triggered by phonological constraints, such as foot binarity and compound stress. In addition, I will show that the same effect is present in English, too. I also propose that the mechanism for the word order change[2] is Nonhead Fronting, by which a syntactic nonhead is moved to the front of a compound. Although various movements have been proposed in morphological literature (e.g. Halle and Marantz 1993), Nonhead Fronting has not. Finally, I show that Nonhead Fronting is similar to XP movement by adjunction in syntax.

2. The patterns

Chinese has a variety of compounds, among which nominal compounds are the most common (for the distinction between compounds and phrases in Chinese, see Dai 1992, Duanmu 1997b). Word order variations are found in two kind of nominal compounds, [V-O N] compounds, exemplified in (1), and [X Y N] compounds, discussed in section 2.2. The patterns discussed below are strong tendencies, but exceptions can be found, some of which will be discussed.[3]

2.1. [V-O N] compounds

I will consider [V-O N] compounds that contain a verb (V), the object (O) of the verb, the head noun (N), and optionally the modifier (M) of the object. With regard to word length, I will only consider monosyllables and disyllables.[4] For convenience, I will refer to each pattern with an abbreviation, in which monosyllables are indicated by V, M, O, and N, and disyllables are indicated by VV, MM, OO, and NN. For example, [V O N] has monosyllabic V, O, and N, and [OO VV N] has a disyllabic O, a disyllabic V, and a monosyllabic N. The compound patterns, along with their corresponding phrasal forms, are given in (2), where the verb is monosyllabic, and in (3), where the verb is disyllabic (see Appendix for actual examples).[5]

(2) Compounds with a monosyllabic verb

	Phrase	Compound
a.	[[V O] N]	[[V O] N]
b.	[[V O] NN]	[[V O] NN]
c.	[[V OO] N]	?[OO [V N]] (?[[V OO] N])
d.	[[V OO] NN]	?[[V OO] NN]
e.	[[V [M O]] N]	?[[M O] [V N]] (?[[V [M O]] N])
f.	[[V [M O]] NN]	?[[V [M O]] NN]
g.	[[V [M OO]] N]	?[[M OO]] [V N]] (?[[V [M OO]] N])
h.	[[V [M OO]] NN]	?[[V [M OO]] NN]
i.	[[V [MM O]] N]	[MM [[V O] N]] (?[[MM O] [V N]])
j.	[[V [MM O]] NN]	[MM [[V O] NN]]
k.	[[V [MM OO]] N]	?[[V [MM OO]] N] (?[[MM OO] [V N]])
l.	[[V [MM OO]] NN]	?[[V [MM OO]] NN]

(3) Compounds with a disyllabic verb

	Phrase	Compound
a.	[[VV O] N]	?[[O VV] N]
b.	[[VV O] NN]	?[[O VV] NN]
c.	[[VV OO] N]	[OO [VV N]]

d.	[[VV OO] NN]	[OO [VV NN]]
e.	[[VV [M O]] N]	[[M O] [VV N]]
f.	[[VV [M O]] NN]	[[M O] [VV NN]]
g.	[[VV [M OO]] N]	[[M OO] [VV N]]
h.	[[VV [M OO]] NN]	[[M OO] [VV NN]]
i.	[[VV [MM O]] N]	[[MM O] [VV N]]
j.	[[VV [MM O]] NN]	[[MM O] [VV NN]]
k.	[[VV [MM OO]] N]	[[MM OO] [VV N]]
l.	[[VV [MM OO]] NN]	[[MM OO] [VV NN]]

The bracketing of the phrases is not controversial. The bracketing of a compound, if it differs from that of the phrase, is usually derived by moving one of the constituents and adjoining it to the left of the expression (see below). For example, in (2i) MM is moved, and in (3f) [M O] is moved. In (3a) and (3b), however, O is moved but not all the way out. Empty syntactic elements are ignored.

The compound word order is primarily determined by the syllable count of O, M, V, and N, and not by the semantics or the syntax of the words. For example, (2a) and (2c) are syntactically identical, yet (2a) has just one word order, which is well-formed, whereas (2c) has two word orders, neither of which is very good.[6] The difference between (2a) and (2c) is solely due to the fact that O is monosyllabic in (2a) but disyllabic in (2c). Similarly, the word order difference between (2a) and (3a) is solely due to the fact that V is monosyllabic in (2a) but disyllabic in (3a).

Many of the compounds are productive. For example, (3d), (3f), and (3l) are fully productive. Similarly, (2a) and (2b) are fully productive for certain head nouns, such as [ji] 'machine' and [xiansheng] 'mister'. Thus, [[xie shu] ji] 'write book machine' and [[mai shu] ji] 'sell book machine' are perfect compounds that I have not heard before. In contrast, [gou] 'dog' does not seem to work so well, and [[chi rou] gou] 'eat meat dog' and [[yao ren] gou] 'bite person dog' sound only potential to me (despite the perfect existing [[kan jia] gou] 'watch house dog'). Some compounds are much less productive. For example, the only established example of (2d) I can think of is [dong naojin yeye] 'use brain grandpa --> The Wise Grandpa' (a newspaper columnist who answers children's questions), which does not sound fully good prosodically. Similarly, I cannot think of an established example of (2h).

Nevertheless, compounds like (2d) and (2h) can be made quite readily (as the two examples of (2d) and (2h) in the Appendix are), even though they do not sound fully good.

Totally bad compound word orders are not listed; for example, (2a) cannot be [O V N], or [V N O], or [N V O]. Forms preceded by a question mark are not always good, but they can occur; in such cases, speakers may prefer to use a phrase instead. The marked forms often have an alternative pattern, given in parentheses, which is not always good either. The choice between the alternatives depends on various factors, which will be discussed. For some marked forms, such as (2d), the alternative is rare, so it is not given; but exceptions can be found.[7] Finally, forms without a question mark are fully good. (4) and (5) summarize the patterns.

(4) a. When the verb is disyllabic VV, the object must be fronted.

E.g. all patterns in (3)

b. A compound should start with a disyllabic unit.

E.g. OO in (3c), [M O] in (3e), and MM in (3i) are good.

(2d) and (3a) are violations; [M OO] is an exception (see below)

c. [V N] is often marginal.

E.g. first pattern of (2c) and (2e)

(5) a. Syntactic heads cannot move:

Verb, (head) Noun, Object (when there is Modifier)

b. Syntactic non-heads can move:

Object (without Modifier), Modifier, Modifier-Object

2.2. [X Y N] compounds

In [X Y N] compounds, X and Y are modifiers of N, such as [daxing hanyu cidian] 'large Chinese dictionary'. The ordering of pre-nominal modifiers in English is restricted by the meaning of the modifiers (cf. Quirk et al 1972). For example, a partial hierarchy of modifier ordering is Size > Shape > Color > Provenance, where '>' means 'precedes'. In addition, Sproat and Shih (1991) have argued, quite persuasively, that this hierarchy is not special for English but common to all languages. Thus in (6), 'large' must precede 'Chinese' for both English and Chinese.

(6) a. Daxing Hanyu Cidian
large Chinese dictionary
'A Large Chinese Dictionary'

b. * Hanyu Daxing Cidian
Chinese large dictionary
* 'A Chinese Large Dictionary'

However, in some cases, the default modifier order is violated. This was noted in Lü (1979), Lu (1989), Lu and Duanmu (1991), and others. An example is given in (7).

(7) a. Hanyu Da Cidian
Chinese large dictionary
'A Large Chinese Dictionary'

b. ?? Da Hanyu Cidian
large Chinese dictionary

Here the preferred modifier order is reversed. The reason for the word order switch is that the Chinese word for 'big' is disyllabic in (6) but monosyllabic in (7). Lu (1989:49) accounts for this effect by suggesting that an [X Y N] cannot be 'large in the middle'. In (7b) the middle word is larger (longer) than the initial word, therefore (7b) is ill-formed. The same applies to (8).

(8) a. Sichuan Bei Lu
Sichuan North Road
'North Sichuan Road'

b. ?? Bei Sichuan Lu
North Sichuan Road

The semantics indicates that 'north' should be in initial position, as in (8b), since 'Sichuan' and 'road' form a closer unit. But since (8b) is 'large in the middle', (8a) becomes the preferred form. However, despite Lu's generalization, the nature of the restriction has remained unclear.

3. Analysis

I propose that word order movement in Chinese compounds is triggered by phonology. I will present my analysis in a theory-neutral way. I first introduce a few constraints, then I analyze the data.

3.1. The constraints

I will assume five constraints, which are given in (9).

(9) a. Left: Main word and compound stress is initial in Chinese.

b. Foot Binarity: A foot should be (at least) two syllables long.

c. VO Stress (does not apply within a foot): The verb has less stress than its object.

d. Cyclicity: Metrical structure is built from smaller units to larger units.

e. IC Well-formedness: The immediate constituents of a compound must be well-formed.[8]

For discussion on foot and/or stress in Chinese, see Shih (1986), Yip (1992, 1994), Ao (1993), Chen (1993), Wang and Wang (1993), Lin (1994), and Duanmu (1995).[9] Foot Binarity was discussed in Prince (1980) and has since become a well-known metrical constraint. The effect of VO Stress in English was discussed in Chomsky and Halle (1968), and the effect in Shanghai Chinese was discussed in Duanmu (1995). In fact, according to Cinque (1993), VO Stress should be universal. The condition that VO Stress does not apply within a foot will be discussed later. Cyclicity was first proposed by Chomsky, Halle, and Lukoff (1956) and has since become a well-known phonological constraint, especially in stress assignment.[10] It is found in both Mandarin Chinese (Shih 1986) and Shanghai Chinese (Duanmu 1995). Finally, IC Well-formedness is largely self-evident. For example, since English does not have *'move-truck' (a truck for moving things), *'move-truck driver' is bad. On the other hand, since English has 'tow-truck', so 'tow-truck driver' is good (i.e., it does not violate IC Well-formedness).[11]

Since I am offering a metrical analysis and will mark foot boundaries, it is necessary to explain what the boundaries based on. There are three pieces of evidence I use. First, while there is a lack of native intuition for stress, there is a fairly clear native intuition for the prosodic grouping of syllables. For example, in (2b) the judgment is [V O / NN] (where the grouping boundary is indicated by a slash), and in (2d) the judgment is [V / OO / NN]. Second, Shih (1986) and Chen (1993) have argued, on the basis of the Mandarin Third Tone Sandhi, that there is a foot formation process, in which a foot is built over each disyllabic syntactic unit, whether it is one disyllabic morpheme or two monosyllabic morphemes. Third, in some Wu dialects, such as Nantong (Ao 1993) and Shanghai (Duanmu 1995), foot domains coincide with tonal domains, which are unambiguously determinable. In most cases, these pieces of evidence make the same predictions, which will be the basis for foot boundaries in the present analysis.

3.2. [X Y N] compounds

I follow Sproat and Shih (1991) in assuming that there is a default ordering among multiple modifiers of a noun. Any ordering different from the default is the result of word movement. First, consider (6). As in English, the

default ordering is 'large' preceding 'Chinese'. (6b) is bad because it violates this ordering. Next we consider whether (6a) is well-formed metrically. The analysis is shown in (10), where ( ) = foot boundaries, and XX, YY, NN indicate disyllabic words.

(10) [XX [YY NN]]

```
 x
 x    x
 x    x    x
(XX) (YY) (NN)
```

Following Kayne (1994), I assume that morphosyntactic structures are strictly binary branching. In addition, I assume that the structure for the meaning in (6a) is [XX [YY NN]] instead of [[XX YY] NN] (the latter would mean 'Dictionary of Large Chinese', assuming there is a language called 'Large Chinese'). On the first cycle, each word forms a left-headed disyllabic foot.[12] The second cycle is [YY NN], where YY gets more stress by Left. On the final cycle, XX gets more stress by Left. The result satisfies all the constraints in (9), so (10) is well-formed in all respects. Next we consider [X [YY NN]], seen in (7b) and analyzed in (11).

(11) [X [YY NN]]

```
a.      x                          b.
        x   x                              x
        x   x    x                         x    x
    * (X) (YY) (NN)                    * X (YY) (NN)
```

The monosyllabic X does not form a binary foot. If it forms a monosyllabic foot, as in (11a), it violates Foot Binarity. If it is unfooted, as in (11b), it violates Left.[13] Thus, neither form is good metrically. Next consider (7a), which has undergone word order switch. This is shown in (12).

(12) [YY [X NN]]

```
a.      x                          b.
        x    x                            x
        x    x   x                       x      x
    * (YY) (X) (NN)                    * (YY) X (NN)
```

Again, I assume that the structure of (12) is [YY [X NN]], and not [[YY X] NN]. The reason is that the constituent [X NN] 'large dictionary' is semantically appropriate for this compound, but the constituent [YY X] 'Chinese large' is not. In addition, we will see below that [YY [X NN]] gives the correct foot patterns but [[YY X] NN] does not. Now in (12), if X is metrified, it violates Foot Binarity. If X is unmetrified, Left is violated in the inner compound [X NN]. Since both structures are bad, we do not expect [YY [X NN]] to occur. But it does, as seen in (7a). It turns

out that the actual foot pattern is neither (12a) or (12b) but (YY)(X NN), as shown in (13).

(13) [YY [X NN]]

```
 x
 x    x
(YY) (X NN)
```

This structure satisfies all the constraints in (9). In particular, the trisyllabic foot (X NN) satisfies both Foot Binarity and Left.[14] However, (X NN) raises two questions. First, can [M NN] (where M is a monosyllabic modifier) always form (M NN)? Second, why can't X and YY in (11) form (X YY) in the same way? The answer to the first question is no. As Lu and Duanmu (1991) note, the preferred patterns for a modifier-noun compound is [MM NN], [MM N], and [M N], but not [M NN]. This is exemplified in (14).

(14)	a.		meitan	shangdian
	b.		meitan	dian
	c.		mei	dian
	d.	*	mei	shangdian
			'coal	store'

Both [mei] and [meitan] mean 'coal', and both [dian] and [shangdian] mean 'store'. The three good patterns are shown in (15).

```
(15)  a.  x                    b.                    c.
          x    x                  x                     x
         (MM) (NN)              (MM) N                (M N)
```

It is clear that (15a) and (15c) are good metrical structures. In addition, the unfooted N in (15b) does not violate either Foot Binarity or Left.[15] Thus all the three forms are good. Next we consider the bad pattern [M NN], which is shown in (16).

```
(16)  a.     x                 b.
             x   x                     x
      *     (M) (NN)            *    M (NN)
```

If M is metrified, it violates Foot Binarity. If M is not metrified, there is a violation of Left. In either case the metrical structure is bad.[16] In order to get a trisyllabic foot (M NN), one must undo the foot structure built over NN on the first cycle. Evidently, this a costly operation, probably reflecting some structure preservation principle. For this reason, (M NN) compounds, while still found, are not preferred forms. But if a (M NN) compound already exists, it can form part of a larger compound as such. In other words, (X NN) in (13) is licensed by the fact that [da

cidian] 'large dictionary' is an independent compound, and the lack of (X YY) in (11) is because foot restructuring is not available to merge X with YY.

We have accounted for [X YY NN]. Next we consider [X YY N], exemplified in (6). The metrical structure of the original word order is shown in (17).

(17) [X [YY N]]

```
a.      x                          b.
        x   x                              x
    *  (X) (YY) N                      *  X (YY) N
```

Again, if X is metrified, there is a violation of Foot Binarity, and if it is not metrified, there is a violation of Left. After the word order switch, we get [YY [X N]], as shown in (18), which satisfies all the constraints.

(18) [YY [X N]]

```
 x
 x    x
(YY) (X N)
```

To summarize, I have shown that word order change in [X Y N] compounds is motivated by phonology. In particular, if the original word order has a good metrical structure, no ordering change takes place. If the original word order has a bad metrical structure, and if the resulting word order has a good one, word order change can take place.

3.3. Nonhead Fronting

Let us take a closer look at the mechanism that enables words to move. First, consider free scrambling. If word order can be freely scrambled, a three-word compound [W1 W2 W3] will have six possible word orders, each of which has two possible branching structures. This gives a total of 12 patterns, as shown in (19).

(19)

[W1 [W2 W3]]	[[W1 W2] W3]
[W1 [W3 W2]]	[[W1 W3] W2]
[W2 [W1 W3]]	[[W2 W1] W3]
[W2 [W3 W1]]	[[W2 W3] W1]
[W3 [W1 W2]]	[[W3 W1] W2]
[W3 [W2 W1]]	[[W3 W2] W1]

Let us consider which ones are possible and which ones not. We see in (7) that [X YY NN] is changed to [YY X NN], which is ambiguous between [YY [X NN]] and [[YY X] NN]. In (12) and (13) I assumed [YY [X NN]] based on semantic appropriateness. There is also phonological evidence. In particular, because of Cyclicity, [YY [X NN]] and [[YY X] NN] produce different metrical structures. While [YY [X NN]] gives (YY)(X NN), [[YY X] NN] gives (YY) X (NN). This is shown in (20).

(20) [YY [X NN]] [[YY X] NN]

```
 x                          x
 x    x                     x      x
(YY) (X NN)                (YY) X (NN)
```

As mentioned earlier, [YY [X NN]] depends on (X NN) being a trisyllabic foot. In [[YY X] NN], X is not in an initial position, so it can remain unmetrified without violating Left. In general, [[MM N] NN] compounds cannot form (MM)(N NN) but must form (MM) N (NN), as shown in (21).

(21) [[Monggu Yu] Cidian] --> (Monggu) Yu (Cidian) *(Monggu)(Yu Cidian)

Mongolia language dictionary

'Dictionary of the Mongolian Language'

It is clear then that the branching structure of a compound is determinable from its foot pattern. The same is true for (7), where [X YY N] is changed to [YY X N], which is ambiguous between [YY [X N]] and [[YY X] N]. [YY [X N]] gives the correct foot structure (YY)(X N), as seen in (18). [[YY X] N] gives a different foot structure, as shown in (22).

(22) [[YY X] N]

```
                            x
 x                          x    x
(YY) X N                 * (YY) (X N)
```

Since X is not in an initial position, it need not be metrified. Similarly, N need not be metrified either. In general, [[MM N] N] compounds cannot form (MM)(N N) but must form (MM) N N. This is exemplified in (23).

(23) [[Emei Shan] Lu] --> (Emei) Shan Lu[17] * (Emei)(Shan Lu)

Emei mountain road

'Mt. Emei Road'

We have now determined that [X [YY NN]] changes to [YY [X NN]] and [X [YY N]] changes to [YY [X

N]]. We ask next whether these are the only good patterns. For [X [YY NN]], one can think of [[X NN] YY], and for [X [YY N]], one can think of [[X N] YY]. Both give good metrical structures, as shown in (24).

(24) a. [[X NN] YY]

```
 x
 x      x
(X NN) (YY)
```

b. [[X N] YY]

```
 x
 x     x
(X N) (YY)
```

In (24a), (X NN) is good because [da cidian] 'large dictionary' is available, and there is no violation of any constraint. Nor is there any violation in (24b). But neither (24a) nor (24b) is possible for (7) and (8). Clearly, then, words cannot be freely scrambled. Instead, there must be restrictions on word movement. Assuming that only leftward word movement is possible (Larson 1988, Kayne 1994), our data suggest two generalizations. First, the head noun does not move. Second, the moved element is adjoined to the left of the original structure. These generalizations are stated in (25), which I call Nonhead Fronting.

(25) Nonhead Fronting:

The only possible movement in a compound is to front a syntactic nonhead in the following way: [...Nonhead...] --> [Nonhead$_i$ [...t$_i$...]].

Nonhead Fronting reduces possible word orders drastically. For example, in [M1 [M2 N]], N is the syntactic head and M1 and M2 are the nonheads. There are three possible movements. First, M1 can move, giving [M1 [t [M2 N]]]. Second, M2 can move out of [M2 N] only, giving [M1 [M2 [t N]]]. Third, M2 can move out of the entire compound, giving [M2 [M1 [t N]]]. Since the trace 't' does not carry stress, the three results are metrically equivalent to [M1 [M2 N]], [M1 [M2 N]], and [M2 [M1 N]] respectively. The first two movements turn out to be vacuous, since the results are the same as the original structure. The only meaningful movement is the third, which is the same as the change from [X [Y N]] to [Y [X N]] that we have discussed. As a second example, consider [[M N1] N2], which has two nonheads, M and [M N1]. Fronting [M N1] is vacuous. Fronting M gives [M [[t N1] N2]], which is metrically the same as [M [N1 N2]]. In other words, the only meaningful move is fronting M. This prediction is correct. First, (26) shows that N1 cannot be fronted.

(26) a. [[Da Yushu] Lu]
big elm road
'[[Big Elm] Road]'

b. *[Yushu [Da Lu]]
elm big road
'[[Big Elm] Road'

The badness of (26b) (for the intended meaning) is not phonological, since its metrical structure is good, as seen in (27) (which is a good compound for a different meaning).

(27) [Yushu [Da Lu]]

```
 x
 x    x
(SS) (S S)
```

Instead, the badness of (26b) is due to Nonhead Fronting, which forbids moving the syntactic head [Yushu].

Second, we consider fronting M in [[M N1] N2], using a [[MM N] N] compound. After fronting MM, we get [MM [[t N] N]], which is metrically the same as [MM [N N]], which should form (MM)(N N). However, we have seen in (23) that (MM)(N N) is not possible for such a compound. Why then does the nonhead MM fail to be fronted here? The answer is that there is no motivation. Specifically, [[MM N] N] already has a good metrical structure, as shown in (28).

(28) [[MM N] N]

```
 x
(MM) N N
```

Since the monosyllabic Ns are not metrified, there is no violation of Foot Binarity. In addition, since neither N is in an initial position, there is no violation of Left. Because there is no violation of any constraint, there is no motivation to front MM. Similarly, there will be no movement for [[MM NN] N] either, since its metrical structure is already good.

In summary, I have proposed that the only word movement in a compound is Nonhead Fronting. In addition, movement occurs only if the original word order does not have a good metrical structure and if the resulting one does.

3.4. [V-O N] compounds

I will assume that at some underlying level all [V-O N] compounds have the same word order, shown in (29), where the empty subject ø has the same reference as the head noun and where M is optional.

(29) $[[ø_i\ [V\ [M\ O]]]\ N_i]$

Since empty elements do not carry stress, I will often ignore them. (29) has the same word order as the corresponding phrase. In addition, (29) agrees with Kayne's (1994) proposal that [S [V O]] is the underlying word

order universally. Finally, (29) agrees with the fact that Chinese nominals are head final.[18] Whether (29) derives from a deeper level of representation will not be explored.[19]

The patterns of [V-O N] compounds are summarized in (4) and (5). It can be seen that (5) is already covered by Nonhead Fronting. (4) is repeated in (30).

(30) a. When the verb is disyllabic VV, the object must be fronted.

b. A compound should start with a disyllabic unit.

c. [V N] is often marginal.

[V N] is mostly marginal, so are compounds containing it, owing to IC Well-formedness. The marginality of [V N] (where N is the logical subject of the transitive V) remains unclear. In any case, [V N] compounds in English, such as 'tow truck', are also unproductive (e.g., 'move truck' is bad). In contrast, for reasons that again remain unclear, [VV N] is always good in Chinese, as seen in (3c, e, g, i).

(30a) follows from VO Stress and Left. Specifically, since VV is disyllabic, it forms a binary foot and has stress. Now VO Stress requires the object to have greater stress, yet Left requires main stress to be initial. This in effect forces the object to be fronted.

Finally, consider (30b), which rules against compounds that start with a monosyllabic unit, such as (2d) and (3a) (but not (2a) or (3e), where [V O] and [M O] serve as a disyllabic unit). In particular, if the initial monosyllable is stressed, it violates Foot Binarity, and if it is unstressed, it violates Left. This is exemplified with (3a) in (31).

(31) [[O VV] N]

```
a.      x                    b.                          c.
        x   x                        x                          x
    * (O) (VV) N             * O (VV) N                 ? (O VV) N
```

First, VV forms a binary foot. Then in [O VV], Left requires main stress to fall on O. But if O gets main stress, it violates Foot Binarity, and if it does not, it violates Left. The only solution is for [O VV] to form a trisyllabic foot. This is, however, unproductive and works for marked cases only.

3.5. Summary

I have analyzed the compound patterns, using the constraints in (9). The analysis makes two points. First,

word order changes are triggered by phonological requirements. Second, the mechanism for word order change is Nonhead Fronting given in (25).

4. Further issues

4.1. Movement or not?

In my analysis of [V-O N] compounds, I have assumed that the underlying word order is [[$ø_i$ [V [M O]]] N_i], and that deviations from it is the result of movement. However, since I also assume IC Well-formedness, there is the question of whether a movement analysis is really necessary.[20] For example, in [OO [V N]] of (2c), IC Well-formedness requires [V N] to be a good compound. What is the reason then to consider OO to be moved out of [[V OO] N] instead of being added directly as a modifier of [V N]? I suggest that both operations are independently available, with different structures and meanings. For illustration, consider (32).[21]

(32) a. [MM [[V ø] N]]
shitou diao che
stone lift truck
'lifting truck made of stone'

b. [OO_i [[V t_i] N]
shitou diao che
stone lift truck
'truck for lifting stone'

In (32a) 'stone' is not the object of 'lift', but a modifier of 'lifting truck'. In (32b) 'stone' is the object of 'lift'. The ambiguity is captured by the different representations. In (32a) 'stone' is directly added. In (32b) it is moved from the object position of V, as indicated by coindexing. The movement analysis also correctly makes two further predictions. First, in [V-O N] compounds that have undergone no movement, such as (2a) and (2b), there is no structural or semantic ambiguity. Second, in a compound like (33) (a case of (2k)), there is a three-way ambiguity.[22]

(33) a. [[MM NN] [[V ø] N]]
pingguo zhongzi diao che
apple seed lift truck
'lifting truck in the shape of an apple seed'

b. [[MM OO_i] [[V t_i] N]

pingguo zhongzi diao che

apple seed lift truck

'truck for lifting apple seeds'

c. [MM [OO_i [[V t_i] N]]]

pingguo zhongzi diao che

apple seed lift truck

'apple shaped truck for lifting seeds'

In (33a) [MM NN] is directly added as a modifier of [[V ø] N]. In (33b) [MM OO] is moved from the object position of the verb. In (33c) OO is moved from the object position of the verb and MM is directly added as a modifier of [OO_i [[V t_i] N]]. The three ambiguities are properly captured by three different structures.

In summary, the present analysis correctly predicts the ambiguities in compounds whose word orders differ from (29), and the lack of such ambiguities in compounds whose word orders are the same as (29). It is not clear how such facts are to be analyzed in a non-movement approach.

4.2. Nonhead Fronting as XP movement by adjunction

I have proposed that Nonhead Fronting is the only mechanism for word order change in compounds. Nearly all movements predicted by Nonhead Fronting are found, and any movement not predicted by Nonhead Fronting is not found. In particular, the underlying structure (29) has two cases, shown in (34), where M is optional.

(34) a. [[$ø_i$ [V O]] N_i]

b. [[$ø_i$ [V [M O]]] N_i]

Metrically, (34a) is the same as [[V O] N] and (34b) is the same as [[V [M O]] N]. The original word order of (34a) is seen in (2a), among other examples, and that of (34b) is seen in (2f). In (34a), there are two syntactic nonheads, O and [V O]. Ignoring vacuous moves and traces, (34a) can give two new structures, shown in (35).

(35) a. O out of [V O] only [[O V] N]

b. O all the way [O [V N]]

An example of (35a) is seen in (3a), and an example of (35b) is seen in (2c). Next we consider (34b), which has

three syntactic nonheads, M, [M O], and [V [M O]]. Ignoring vacuous moves and traces, (34b) can give rise to four new structures, shown in (36), where (36c) and (36d) subsume (35a) and (35b).

(36)	a.	M out of [V [M O]] only	[[M [V O]] N]
	b.	M all the way	[M [[V O] N]]
	c.	[M O] out of [V [M O]] only	[[[M O] V] N]
	d.	[M O] all the way	[[M O][V N]]

Metrically, (36a) and (36b) are identical, and we have seen such an example in (2i), although there is not enough evidence to distinguish between them. Similarly, (36c) and (36d) are often metrically identical and hard to distinguish, as seen in the discussion of (3e). However, we do have evidence for (36d), which is seen in the discussion of (2e). Overall, then, we do have clear evidence for the two major predictions of Nonhead Fronting: First, both M and [(M) O] can move, and second, the moved item can adjoin either to the left of [V [(M) O]] or to the left of the entire compound.

Nonhead Fronting has a parallel in syntax. According to Chomsky (1994), there are two kinds of movement, head movement and XP movement. A head is the node that starts a projection, and an XP is where the projection ends. This is illustrated in (37).

(37) a.

```
XP
 /\
ZP X'
    /\
   X YP
```

b.

```
X
 /\
Z  X
    /\
   X  Y
```

In (37a) X is the head, which projects to X', which in turn projects to XP. The nodes YP and ZP are maximal projections themselves. As Chomsky (1994) suggests, once we know the structural relations, there is no need to use X' and XP, and (37a) can be represented as (37b). Using the same method, the underlying word order of [V-O N] compounds can be represented in (38).

(38) a.

```
N
 /\
V  N
 /\
ø  V
    /\
   V  N
       /\
      M  O
```

b.

```
Nb
 /\
Vb  N
 /\
ø  Va
    /\
   V  Na
       /\
      M  O
```

The structural relation in (38a) is unambiguous. For exposition, I label the repeated nodes as Va, Vb, Na, and Nb in

(38b). For convenience, we can still use 'maximal projections' or XPs to refers to the nodes where a projection ends, without implying that a compound can contain phrases.[23] In (38b), therefore, there are five XPs, Nb, Vb, Na, M, and ø, and three heads, O, V, and N.

In head movement, a head moves to join another head. This is usually triggered by the need for verbs to check certain features under functional projections, or for empty head positions to be filled with phonetic material (Hale and Keyser 1993). Since [V-O N] compounds do not contain functional projections or unfilled head positions, head movement is not relevant. In XP movement, there are two cases, substitution and adjunction. In substitution, an XP moves to an empty XP position, typically the Spec of a functional projection, such as the Spec of IP or CP. Since [V-O N] compounds do not contain such projections, substitution is not relevant either. This leaves us with one option to consider, which is XP movement by adjunction.

To narrow the discussion, I will follow Kayne (1994) and assume that adjunction can only be made to the left of an XP and never to the right. Of the five XPs in (38), Nb, Vb, and ø are irrelevant, since their movements are metrically vacuous. For the remaining two, Na and M, adjunction can be made either at Vb or at Nb, which gives a total of four cases in (39) and (40).

(39) a. moving M to Vb

```
    Nb
    /\
Vb  N
 /\
M  Vb
   /\
  ø  Va
     /\
    V  Na
       /\
      t  O
```

b. moving M to Nb

```
  Nb
  /\
M  Nb
    /\
  Vb  N
  /\
ø  Va
    /\
   V  Na
      /\
     t  O
```

(40) a. moving Na to Vb

```
      Nb
      /\
    Vb  N
     /\
   Na  Vb
  /\   /\
 M  O ø  Va
         /\
        V  t
```

b. moving Na to Nb

```
      Nb
      /\
    Na  Nb
   /\   /\
  M  O Vb N
       /\
      ø  Va
         /\
        V  t
```

Ignoring empty elements, these four cases metrically translate into the four patterns in (36), repeated in (41).

(41) a. [[M [V O]] N] same as (39a)

b. [M [[V O] N]] same as (39b)

c. [[[(M) O] V] N] same as (40a)

d. [[(M) O][V N]] same as (40b)

In addition, (35a) is an instance of (41c), and (35b) is an instance of (41d). Thus, what is predicted by Nonhead Fronting corresponds exactly to what is predicted by XP movement by adjunction.[24]

4.3. Halle and Marantz's proposal of morphological movement

Halle and Marantz (1993:114) propose a grammatical model in which morphology takes the output of syntax (S-Structure, or SS) as its input. In addition, they assume (p115) that in SS "there is only hierarchical nesting of constituents, but no left-to-right order among the morphemes. The linear order of morphemes that all sentences exhibit at PF must therefore be established by the rules or principles that relate SS to MS (and PF)." (Halle and Marantz also have provisions for head-to-head movement and affix movement, which do not concern us.) In this section we discuss whether Nonhead Fronting can be interpreted this way, namely, in terms of the rotation of syntactic nodes, assuming that the rotation can be triggered by metrical well-formedness.

We have seen that in [X [YY N]] compounds, where X is a monosyllabic modifier and YY a disyllabic modifier, YY can be fronted to give [YY [X N]]. An example is repeated in (42).

(42)	[X [YY N]]	-->	[YY [X N]]
	Bei Sichuan Lu		(Sichuan) (Bei Lu)
	North Sichuan Road		Sichuan North Road
			'North Sichuan Road'

However, this word order cannot be derived by node rotation, as shown in (43).

(43)

```
a. [X [YY N]]        b. [X [N YY]]
      /\                   /\
     X /\                 X /\
       YY N                 N YY
c. [[YY N] X]        d. [[N YY] X]
      /\                   /\
     /\ X                 /\ X
    YY  N                N YY
```

Node rotation gives four word orders, none of which is the observed one. The same problem exists for [V-O N]

compounds. For example, in (2i) [[V [M O]] N] can become [[M [V O]] N] or [M [[V O] N]], neither of which can be derived through node rotation. I conclude therefore that Nonhead Fronting must be independently available in morphology, besides the movement mechanisms proposed by Halle and Marantz (1993).

4.4. Compound word order in English

Since most of the constraints in the present analysis are general (see (9)), it is natural to ask whether similar interactions between phonological constraints and word order can be found in other languages. Unfortunately, such a survey is beyond the scope of the present study. Still, I will consider some cases in English and suggest that similar effects can be observed.

It can be noted in (2) and (3) that, although the Chinese compounds varied in word order, their English counterparts are consistently [(M) O V N]. The question is why. In fact, the present analysis already provides an answer. In (2) and (3) the English verb has the ending '-ing', so it is at least disyllabic. Thus, the English counterparts are like the Chinese compounds in (3), where the order is also consistently [(M) O V N]. Specifically, in a two-word English compound main stress is usually on the left, and [(M) O] V] satisfies both VO Stress and left-headed compound stress. When the English verb is monosyllabic, without the ending '-ing', the present analysis predicts that the word order [V-O N] can occur, as it does in Chinese. This is indeed the case, as shown by the examples in (44).

(44) break-neck speed

make-shift plan

kill-joy person/attitude

spoil-sport person/attitude

Such English examples correspond to the Chinese [V O N] and [V O NN] compounds in (2a) and (2b), in which the object is not fronted.

The present analysis also offers a better analysis of English compounds like ‘truck driver’ than what is given by Lieber (1983).[25] According to Lieber, the argument structure of ‘truck driver’ suggests that the bracketing is [[truck drive] -er]. However, it is unexplained why the word order in the inner unit is [O V] instead of [V O]. In addition, as Booij (1988) points out, the analysis of [[truck drive] -er] predicts that [truck drive] is a possible

compound, which is not the case. In the present analysis, the underlying structure of 'truck driver' is similar to that of (2a), which is shown in (45).

(45)
```
        N
       / \
      V   N
     /\   |
    ø  V  er
       /\
      V  O
      |  |
    drive truck
```

This structure is ill-formed, because the suffix '-er' needs to be attached to a verb. The problem can be solved by raising the object via Nonhead Fronting, as shown in (46).

(46)
```
        N
       / \
      N   N
      |   /\
    truck V  N
         /\  |
        ø  V er
           /\
          V  t
           |
         drive
```

This structure is metrically equivalent to [truck [drive er]], in which 'er' is able to attach to a verb. (46) also explains the apparent bracketing paradox that syntactically [drive truck] forms a closer unit, in that order, whereas phonologically [drive er] forms a closer unit.

Finally, let us consider [X [YY N]] compounds. I have shown that in such compounds the preferred word order is [YY [X N]] in Chinese, where YY is fronted, but [X [YY N]] in English, where Y cannot be fronted. An example was seen in (11) and repeated in (47).

(47)	a.	[X [YY N]]		b.	[YY [X N]]
	??	Bei Sichuan Lu			Sichuan Bei Lu
		North Sichuan Road		*	Sichuan North Road

In our analysis, the word order change in Chinese is triggered by Left and Foot Binarity. Left requires main stress to fall on the initial syllable, and Foot Binarity requires it to fall on a disyllabic word. The combined effect is for the initial word to be disyllabic. Since X cannot satisfy the requirements but YY can, [YY [X N]] gives a better metrical structure in Chinese. Now, why is [YY [X N]] unavailable in English? I suggest that it is because Left is not

consistent in English. In particular, although in a two-word English compound [A B] main stress usually falls on A, in a three-word compound [A [B C]] main stress is not on A but on B, and occasionally on C (Halle and Vergnaud 1987, Hayes 1995). Because main stress is not initial in English [X [YY N]] compounds, there is no metrical motivation to front YY.[26]

4.5. Lack of word order variation in other compounds

We saw in (2) that there are many other types of compounds in Chinese. However, unlike nominal compounds, these compounds do not exhibit word order variation. The reason should now be clear. In nominal compounds word order variation is initiated by metrical well-formedness. Since non-nominal compounds are usually made of two monosyllabic words, which can form a binary foot, there is no metrical need for changing word order.

5. Conclusions

In this paper I have offered an analysis of word order variation in Chinese compounds. I have argued that word order change is motivated by phonology, in that if the original word order has a bad metrical structure and the resulting word order has a good one, word order change can take place. In addition, I have argued that the mechanism for word order change is Nonhead Fronting, given in (25), which is similar to XP movement by adjunction in syntax. Moreover, I have argued that, as in Chinese, English compounds also exhibit word order variation, although to a lesser extent. The reason English shows less variation is that main stress in English compounds is not consistently initial, therefore there is not always the need to front a disyllabic word to the initial position.

The present analysis offers a solution to a long-standing problem in Chinese phonology and morphology. It also shows that metrical structure plays a crucial role in Chinese, a language that is often thought to lack phonetic stress (beyond a difference between weak and full syllables). This result shows that languages share more in common than they appear.

The fact that Nonhead Fronting is found in compounds raises some theoretical questions with regard to the syntactic, morphological, and phonological components of grammar, and the interfaces among them. For example,

if compounding is part of morphology, morphology must have more movement mechanisms than previously thought. Similarly, if Nonhead Fronting is XP movement by adjunction, the latter being a typical syntactic operation, there is the question of where syntax and morphology end and where phonology begins. For example, in the present analysis, whether Nonhead Fronting applies or not depends on metrical well-formedness. However, in the standard conception of generative grammar, the input to the phonological component is the output of either the syntactic component (Chomsky 1981) or the morphological component (Halle and Marantz 1993); in either case phonology should not be able to trigger either syntactic or morphological movements in retrospect.[27] I leave such questions for further studies.

Notes

*This is an abbreviated version of a longer work. For discussions and comments, I thank Mark Aronoff, Lisa Cheng, Prathima Christdas, Michel DeGraff, Morris Halle, Jim Huang, Michael Kenstowicz, Yafei Li, Yen-hwei Lin, Bingfu Lu, Lesley Milroy, James Myers, Richard Sproat, Moira Yip, and Shangyang Zhao, and some anonymous reviewers. I also thank audiences at the University of Michigan, Michigan State University, University of California at Irvine, and MCWOP-2, where various aspects of this paper were presented.

[1]Since the word order variation phenomenon is true for all Chinese dialects, examples are given in Pinyin, a transcription system that approximates the pronunciation of Standard Mandarin. In addition, since tones are not relevant, they omitted in the transcriptions.

[2]An anonymous reviewer points out that 'word order change' implies a diachronic process. In this article I use 'word order change' and 'word order variation' interchangeably, both referring to a synchronic process.

[3]For example, X in an [X Y N] compound should be disyllabic (cf. section 2.2), but sometimes it can be monosyllabic, as shown in (i),

(i) Xin Ying-Han Cidian
new English-Chinese dictionary
'A New English-Chinese Dictionary'

where the initial unit [xin] is monosyllabic but the medial unit [ying-han] is disyllabic. According to the preferred tendency, (i) should be changed to (ii).

(ii) Ying-Han Xin Cidian
English-Chinese new dictionary

According to Lu (1989:49), there was indeed an editorial debate on whether (i) or (ii) would be a better name of the book. (i) better reflects the semantics and the English word order. (ii) better reflects the Chinese rhythm. The decision finally went for (i), probably because most of the editors were from the foreign languages department, instead of from the Chinese department.

[4]Many disyllables are actually compounds, such as [gong-ju] 'tool' (literally 'work-tool') and [jia-gong] 'process' (literally 'add-work'). As I will discuss below, this fact does not affect the point being made here.

[5]When the compound word order differs from that of the phrase, the compound will have two (or more) meanings. An example of pattern (2c) is shown in (i), which can mean either 'a knife for cutting turnip' or 'a cutting knife made of turnip'.

(i) a.	[MM [[V ø] N]]	b. [OO_i [[V t_i] N]]
	luobo qie dao	luobo qie dao
	turnip cut knife	turnip cut knife
	'cutting knife made of turnip'	'knife for cutting turnip'

In (ia) [luobo] 'turnip' is added directly as the modifier of [[V ø] N] (where 'ø' shows the empty object of the verb). In (ib) [luobo] is moved from the object position of the verb (shown by a coindexed trace). Clearly, only (ib) has the same meaning as the corresponding phrasal form. Compounds that have the same word order as the phrase are not ambiguous. See section 4.1.

[6]As Moira Yip (p.c.) points out, in Optimality Theory (Prince and Smolensky 1993), there should always be a good form, no matter how many constraints it violates. But it is not the case here. For example, (2d) is the only possible form and is still marginal. Why, then, is the best not good enough? I suggest that the principle 'the best candidate is always good' applies to productive structures only, and not to unproductive structures. Compounds are not fully

productive. When one comes across a gap or a marginal form, one can always resort to a phrasal expression instead.

[7]For example, because [V NN] is rare, (2d) usually cannot be [OO [V NN]]. However, when [V NN] is good, [OO [V NN]] is also good. One example of [V NN] (thanks to Jerry Packard) is [kang xueqing] 'oppose serum (anti-serum)', which can give the [OO [V NN] in (i).

(i) [ganmao [kang xueqing]]
flue oppose serum
'flu anti-serum'

[8]As a reviewer points out, IC Well-formedness has related formulations in Optimality Theory. For example, it resembles Base-Identity of Kenstowicz (1995) or Anti-Allomorph of Burzio (1995).

[9]Duanmu (1995) suggested that, whereas compound stress was left-headed in Shanghai, it was right-headed in Taiwanese Chinese. However, the Taiwanese case was based on rather weak data. The crucial example was a nominal with a locative head (p242, (57)-(58)), which could not be extended to other [M N] nominals. In contrast, the Shanghai case was based on a full range of [M N] compounds.

[10]It is possible to interpret cyclicity as an identity constraint in Optimality Theory; see, for example, Kenstowicz (1995) and Duanmu (1997a). Since the interpretation does not affect our analysis, I do not discuss it here.

[11]Obviously, the notion of well-formedness is not limited to syntactic and prosodic well-formedness, but includes whether a compound is available in a language, thanks to James Myers for making this point. For example, *'move-truck' is bad not because it violates syntactic or prosodic constraints, but because it is simply not available in English.

[12]Each of XX, YY, NN here is itself a compound. However, whether a disyllabic unit is a single word or a compound, it always forms a left-headed binary foot. For simplicity, I will often gloss a disyllabic compound as a single word.

[13]One may wonder if there is a separate constraint against an unfooted syllable. I will show shortly that an unfooted syllable is allowed in non-initial positions. In addition, I will not consider the obviously bad case that X carries main stress without being in a foot.

[14]There are other ways to look at why (X)(NN) is worse than (X NN). For example, the first two syllables in (X)(NN) are both stressed, which violates No Stress Clash; in (X NN) there is no stress clash. Alternatively, if Foot Binarity consists of two parts (Hewitt 1994, Green 1995), one can say that (X) violates the 'At Least Two' part, whereas (X NN) violates the 'At Most Two' part. Or one can assume both No Stress Clash and a decomposed Foot Binarity. In any case, while (X NN) is better than (X)(NN), it is not an ideal pattern, as we will see shortly.

[15]An unfooted full syllable does not carry the stress of a disyllabic foot. However, a full Chinese syllable still has more stress than a weak syllable. This is because every full syllable is heavy and constitutes a binary foot at the moraic level, as argued by Duanmu (1993). This explains why full syllables retain their tones but weak syllables lose them. Similarly, a full syllable in the second position of a binary foot also has some stress, which enables it to keep its tone. See Prince (1980) and Kager (1992) for the idea that a language can have both moraic and syllabic feet.

[16]There is an alternative way of looking at why [MM N] is better than [M NN]. This is shown in (i).

(i) a.
```
 x
 x   x
(MM)(N ø)
```
b.
```
 x
 x    x
* (M ø)(NN)
```

Following Burzio (1994), a monosyllable can form a binary foot with a 'zero syllable' (ø). Thus, [MM N] forms two feet, as in (ia). This agrees with observations like Chao (1968) that in a trisyllabic compound the first and third syllables have more stress than the second. (ib) shows the structure of [M NN] with the zero syllable, which does not violate Foot Binarity any more. But (ib) another constraint. According to Burzio, there are two kinds of feet, weak and strong. A foot with a zero syllable or a weak vowel is weak; other feet are strong. When a weak foot and a strong foot occur together, the strong foot will attract main stress. Thus, although English word stress usually falls on the last foot, in (órtho)(dòxy) it falls on the first foot, because the second foot is weak. In (ib) the first foot is weak, so main stress will be attracted to the second foot, which then violates Left.

[17]Once again, with a zero vowel this compound can form two feet, (Emei) Shan (Lu ø). In this case, the first and last syllables have more stress than the middle two, in agreement with Chao (1968). The zero vowel is more readily available in final position. Thus, while (Emei)(Shan ø) is good, (Emei)(Shan ø) Lu is bad, where [Shan] has greater stress than [Lu].

[18]There is an addition argument for (29). As seen in note 5, when a compound has this word order, it has just one meaning, but when a compound has a different word order, it has two meanings. This fact follows from (29) as follows. Since (29) is the underlying word order, there are no empty positions (ignoring the inner subject), so the meaning is not ambiguous. If the word order is not (29), there will be an empty position. The empty position can either be coindexed with the fronted element, or it can be independent from it. The two options give rise to the semantic ambiguities.

[19]In this regard, we note Kayne's (1994) claim that no structure is head final underlyingly. In other words, [V-O N] compounds may have a deeper origin, such as [N [ø [V [O M]]]].

[20]This possibility was raised by Lisa Cheng (p.c.) and an anonymous reviewer.

[21]An anonymous reviewer suggests that 'lifting truck made of steel' is a more felicitous example that 'lifting truck made of stone'. This may be true if one is thinking of real machines. However, a sculpture of a lifting truck, mad of stone, is an entirely natural object.

[22]Again, an anonymous reviewer suggests that a more felicitous example should be given than (33), since 'lifting truck in the shape of an apple seed' and 'apple shaped truck for lifting seeds' seem like fairy-tale objects. One such example is given in (i), where the meanings (ia-c) correspond to the three bracketing structures in (33a-c).

(i) baise suliao diao che
white plastic lift truck

a. 'lifting truck made of white plastics'
b. 'truck for lifting white plastics'
c. 'white truck for lifting plastics'

[23]If both phrases and compounds have minimal and maximal projections, what is the difference between a phrase and a compound beyond the fact that in the former we often use nodes like XP, YP, etc., and in the latter we do not? Unfortunately, this question cannot be adequately answered here.

[24]A reviewer suggests that instead of Nonhead Fronting, one can perhaps assume free scrambling and then let the stress rules pick out the correct patterns. It can be shown, however, that free scrambling without syntactic constraints over-generates, and free scrambling with syntactic constraints is no different from Nonhead Fronting.

[25]Thanks to Rochelle Lieber (p.c.) for some discussion on synthetic English compounds.

[26]Suppose in an English compound [XX [Y NN]], main stress fall on Y. Do we expect Y fronting to get [Y [XX N]], where main stress now falls on the disyllabic XX? The answer is no.

The reason is that by IC Well-formedness, [Y NN] must be an independent compound, where main stress falls on Y. So whatever ensures the well-formedness of [Y NN] ensures the main stress on Y in [XX [Y NN]]. Thus, no word order change is expected in this case.

[27]In this connection, we note certain word movements outside compounds that also seem to be triggered by phonology. For example, Hale and Keyser (1993) discuss a head-to-head movement that is triggered by the need to fill an empty higher head position with phonological material. Similarly, the well-known heavy-NP shift in English seems to be phonologically motivated, as pointed out by Inkelas and Zec (1995).

References

Ao, Benjamin X.P. 1993. Phonetics and phonology of Nantong Chinese. Doctoral dissertation, Ohio State University, Columbus.

Booij, Geert. 1988. The relation between inheritance and argument linking: deverbal nouns in Dutch. In Morphology and modularity : in honour of Henk Schultink, ed. Martin Everaert et al, 57-74. Dordrecht: Foris.

Burzio, Luigi. 1994. Principles of English stress. Cambridge, UK: Cambridge University Press.

Burzio, Luigi. 1995. Surface constraints versus underlying representations. To appear in Current trends in phonology: models and methods, ed. J. Durand and B. Laks. CNRS, Paris X, and University of Salford. University of Salford Publications.

Chao, Yuen-Ren. 1968. A grammar of spoken Chinese. Berkeley, California: University of California Press.

Chen, Matthew. 1993. Lexical and phrasal tone sandhi in Mandarin. Paper presented at the Fifth North America Conference on Chinese Linguistics, May 14-16. Newark, Delaware.

Chomsky, Noam. 1981. Lectures on government and binding. Dordrecht: Foris.

Chomsky, Noam. 1994. Bare phrase structure. MIT occasional papers in linguistics Number 5. Distributed by MIT Working Papers in Linguistics, MIT, Cambridge, MA.

Chomsky, Noam, and Morris Halle. 1968. The sound pattern of English. N.Y.: Harper and Row.

Chomsky, Noam, Morris Halle, and Fred Lukoff. 1956. On accent and juncture in English. In For Roman Jakobson, compiled by Morris Halle, Horace Lunt, Hugh MacLean, and Cornelis van Schooneveld, 65-80. The Hague: Mouton.

Cinque, Guglielmo. 1993. A null theory of phrase and compound stress. Linguistic Inquiry 24.2:239-297.

Dai, John X.L. 1992. Chinese morphology and its interface with the syntax. Doctoral dissertation, Ohio State University, Columbus.

Duanmu, San. 1993. Rime length, stress, and association domains. Journal of East Asian Linguistics 2.1:1-44.

Duanmu, San. 1995. Metrical and tonal phonology of compounds in two Chinese dialects. Language 71.2: 225-259.

Duanmu, San. 1997a. Recursive constraint evaluation in Optimality Theory: evidence from cyclic compounds in Shanghai. To appear in NLLT.

Duanmu, San. 1997b. Wordhood in Chinese. New approaches to Chinese word formation: morphology, phonology and the lexicon in modern and ancient Chinese, ed. Jerome Packard, 135-196. Berlin: Mouton de Gruyter.

Green, Thomas. 1997. The stress window in Piraha: a reanalysis of rhythm in Optimality Theory. Ms., MIT. Available at Rutgers Optimality Archive, ROA-45.

Hale, Kenneth, and Samuel Jay Keyser. 1993. On argument structure and the lexical expression of syntactic relations. In The view from Building 20: Essays in honor of Sylvain Bromberger, ed. Kenneth Hale and Samuel Jay Keyser, 53-109. Cambridge, MA: MIT Press.

Halle, Morris, and Alec Marantz. 1993. Distributed morphology and the pieces of inflection. In The view from Building 20: Essays in honor of Sylvain Bromberger, ed. Kenneth Hale and Samuel Jay Keyser, 111-176. Cambridge, MA: MIT Press.

Halle, Morris, and Jean-Roger Vergnaud. 1987. A essay on stress. Cambridge, Mass.: MIT Press.

Hayes, Bruce. 1995. Metrical stress theory: Principles and case studies. Chicago: University of Chicago Press.

Hewitt, Mark. 1994 . Deconstructing Foot Binarity in Koniag Alutiiq. Ms., University of British Columbia. Available as ROA 12.

Inkelas, Sharon, and Draga Zec. 1995. Syntax-phonology interface. In The handbook of phonological theory, ed. John Goldsmith, 535-549. Cambridge, MA: Blackwell.

Kager, René. 1992. Shapes of the generalized trochee. WCCFL 11:298-312.

Kayne, Richard S. 1994. The antisymmetry of syntax. Cambridge, MA: MIT Press.

Kenstowicz, Michael. 1995. Base-Identity and Uniform Exponence: alternatives to cyclicity. To appear in Current trends in phonology: models and methods, ed. J. Durand and B. Laks. CNRS, Paris X, and University of Salford. University of Salford Publications.

Larson, Richard. 1988. On the double object construction. Linguistic Inquiry 19:335-391.

Lieber, Rochelle. 1983. Argument linking and compounds in English. Linguistic Inquiry 14.2:251-285.

Lin, Hua. 1994. Against domain-final stress in Mandarin. Paper presented at the Sixth North American Conference on Chinese Linguistics, May 1994. Los Angeles: University of Southern California.

Lu, Bingfu. 1989. Hanyu dingyu de fenlei ji yuxu [Classes and order of nominal modifiers in Chinese]. Hua Wen Shij Je 1989.4:44-52.

Lu, Bingfu, and San Duanmu. 1991. A case study of the relation between rhythm and syntax in Chinese. Paper presented at the Third North America Conference on Chinese Linguistics, May 3-5, Ithaca.

Lü, Shuxiang. 1979. Hanyu yufa fengxi wenti [Problems in the analysis of Chinese grammar], Peking: Shangwu Yinshuguan.

Prince, Alan. 1980. A metrical theory for Estonian quantity. Linguistic Inquiry 11:511-562.

Prince, Alan, and Paul Smolensky. 1993. Optimality theory: Constraint interaction in generative grammar. Ms., Rutgers University.

Quirk, Randolph, Sidney Greenbaum, Geoffrey Leech, and Jan Svartvik. 1972. A grammar of contemporary English. New York: Seminar Press.

Shih, Chi-lin. 1986. The prosodic domain of tone sandhi in Chinese. Doctoral dissertation, University of California, San Diego.

Sproat, Richard, and Chilin Shih. 1991. The cross-linguistic distribution of adjective ordering restrictions. In Interdisciplinary approaches to language: Essays in honor of S.-Y. Kuroda, ed. Carol Georgopoulos, and Roberta Ishihara. Dordrecht: Kluwer Academic Publishers.

Wang, Jing, and Lijia Wang. 1993. Putonghua duo yinjie ci yinjie shi chang fenbu moshi [The types of relative lengths of syllables in polysyllabic words in Putonghua]. Zhongguo Yuwen 1993.2 (733): 112-116.

Yip, Moira. 1992. Prosodic morphology in four Chinese dialects. Journal of East Asian Linguistics 1.1:1-35.

Yip, Moira. 1994. Isolated uses of prosodic categories. In Perspectives in phonology, ed. Jennifer Cole and Charles Kisseberth, 293-311. CSLI Lecture Notes No.51. Center for the Study of Language and Information, Standford University.

Appendix

1. Compounds with a monosyllabic verb

	Phrase	Compound
a.	[V O N]	[V O N]
	qie cai de dao	qie cai dao
	cut vegetable DE knife	cut vegetable knife
	'knife that cuts vegetables'	'vegetable-cutting knife'
b.	[V O NN]	[V O NN]
	qie cai de gongju	qie cai gongju
	cut vegetable DE tool	cut vegetable tool
	'tool that cuts vegetables'	'vegetable-cutting tool'
c.	[V OO N]	?[OO V N] (?[V OO N])
	qie luobo de dao	luobo qie dao
	cut turnip DE knife	turnip cut knife
	'knife that cuts turnips'	'turnip-cutting knife'
d.	[V OO NN]	?[V OO NN]
	qie luobo de gongju	qie luobo gongju
	cut turnip DE tool	cut turnip tool
	'tool that cuts turnips'	'turnip-cutting tool'
e.	[V M O N]	?[M O V N] (?[V M O N])
	wa gua zi de dao	gua zi wa dao
	scoop melon seed DE knife	melon seed scoop knife
	'knife that scoops melon seeds'	'melon seed-scooping knife'
f.	[V M O NN]	?[V M O NN]
	wa gua zi de gongju	wa gua zi gongju
	scoop melon seed DE tool	scoop melon seed tool
	'tool that scoops melon seeds'	'melon seed-scooping tool'
g.	[V M OO N]	?[M OO V N] (?[V M OO N])
	ke jin jiezi de dao	jin jiezi ke dao
	carve gold ring DE knife	gold ring carve knife
	'knife that carves gold rings'	'gold ring-carving knife'
h.	[V M OO NN]	?[V M OO NN]
	ke jin jiezi de gongju	ke jin jiezi gongju
	carve gold ring DE tool	carve gold ring tool
	'tool that carves gold rings'	'gold ring-carving tool'
i.	[V MM O N]	[MM V O N] (?[MM O V N])
	xue luobo pi de dao	luobo xue pi dao
	peel turnip skin DE knife	turnip peel skin knife
	'knife that peels turnip skin'	'turnip skin-peeling knife'
j.	[V MM O NN]	[MM V O NN]
	xue luobo pi de gongju	luobo xue pi gongju
	peel turnip skin DE tool	turnip peel skin tool
	'tool that peels turnip skin'	'turnip skin-peeling tool'
k.	[V MM OO N]	?[V MM OO N] (?[MM OO V N])
	xi pingguo zhongzi de gang	xi pingguo zhongzi gang
	wash apple seed DE pot	wash apple seed pot
	'pot that washes apple seeds'	'apple seed-washing pot'
l.	[V MM OO NN]	?[V MM OO NN]
	xi pingguo zhongzi de gongju	xi pingguo zhongzi gongju
	wash apple seed DE tool	wash apple seed tool
	'tool that washes apple seeds'	'apple seed-washing tool'

2. Compounds with a disyllabic verb

	Phrase	Compound
a.	[VV O N]	?[O VV N]
	jiagong cai de dao	cai jiagong dao
	process vegetable DE knife	vegetable process knife
	'knife that processes vegetables'	'vegetable-processing knife'
b.	[VV O NN]	?[O VV NN]
	jiagong cai de gongju	cai jiagong gongju
	process vegetable DE tool	vegetable process tool
	'tool that processes vegetables'	'vegetable-processing tool'
c.	[VV OO N]	[OO VV N]
	jiagong luobo de dao	luobo jiagong dao
	process turnip DE knife	turnip process knife
	'knife that processes turnips'	'turnip-processing knife'
d.	[VV OO NN]	[OO VV NN]
	jiagong luobo de gongju	luobo jiagong gongju
	process turnip DE tool	turnip process tool
	'tool that processes turnips'	'turnip-processing tool'
e.	[VV M O N]	[M O VV N]
	jiagong gua zi de dao	gua zi jiagong dao
	process melon seed DE knife	melon seed process knife
	'knife that processes melon seeds'	'melon seed-processing knife'
f.	[VV M O NN]	[M O VV NN]
	jiagong gua zi de gongju	gua zi jiagong gongju
	process melon seed DE tool	melon seed process tool
	'tool that processes melon seeds'	'melon seed-processing tool'
g.	[VV M OO N]	[M OO VV N]
	jiagong jin jiezi de dao	jin jiezi jiagong dao
	process gold ring DE knife	gold ring process knife
	'knife that processes gold rings'	'gold ring-processing knife'
h.	[VV M OO NN]	[M OO VV NN]
	jiagong jin jiezi de gongju	jin jiezi jiagong gongju
	process gold ring DE tool	gold ring process tool
	'tool that processes gold rings'	'gold ring-processing tool'
i.	[VV MM O N]	[MM O VV N]
	jiagong luobo pi de dao	luobo pi jiagong dao
	process turnip skin DE knife	turnip skin process knife
	'knife that processes turnip skin'	'turnip skin-processing knife'
j.	[VV MM O NN]	[MM O VV NN]
	jiagong luobo pi de gongju	luobo pi jiagong gongju
	process turnip skin DE tool	turnip skin process tool
	'tool that processes turnip skin'	'turnip skin-processing tool'
k.	[VV MM OO N]	[MM OO VV N]
	jiagong pingguo zhongzi de dao	pingguo zhongzi jiagong dao
	process apple seed DE knife	apple seed process knife
	'knife that processes apple seeds'	'apple seed-processing knife'
l.	[VV MM OO NN]	[MM OO VV NN]
	jiagong pingguo zhongzi de gongju	pingguo zhongzi jiagong gongju
	process apple seed DE tool	apple seed process tool
	'tool that processes apple seeds'	'apple seed-processing tool'