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# Feature Representations and Logical Compatibility between Temporal Adverbs and Aspects

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### Abstract

In this paper, we propose clear-cut definitions of distinct temporal adverbs and provide descriptive features for each class of temporal adverbs. By measuring time points in temporal axis, we revise and reclassify the temporal adverbs listed in [Lu and Ma 1999] into four classes of semantic roles, namely, time, frequency, duration, and time manner. The descriptive features enable us to distinguish temporal relations and predict logical compatibility between temporal adverbs and aspects.

**Keywords:** Temporal Adverbs, Aspects, Temporal Schema, Speaking Time, Reference Time, Event Time

### 1. Introduction

There are about 130 temporal adverbs in Mandarin Chinese. Lu and Ma [1999] classified temporal adverbs into two groups, speaking-time related adverbs (abbr: ST-related adverbs, 定時時間副詞) and reference-time related adverbs (abbr: RT-related adverbs, 不定時時間副詞). The ST-related adverbs consist of 27 temporal adverbs, which are subdivided into three subclasses. In the class of RT-related adverbs, 104 temporal adverbs are listed and subdivided into 18 subclasses. In Lu and Ma's definition, ST-related adverbs modify events that happen at specific time points; RT-related adverbs modify events that have happened in the past or will happen in the future. However, the subdivisions are vague, and the definition is incomprehensible. For example, *cengjing 曾經, ceng 曾, yeyi* 業已 and *yejing* 業經 are grouped into two different subclasses of ST-related adverbs. The former two are grouped into the same subclass, which includes actions or situations that happened or existed before the speaking time. The later two are grouped into the same subclass, which includes actions or situations that have been completed or have occurred. In fact, it is difficult to differentiate between actions or situations that have 'happened' or have 'completed', especially when the situation type is an achievement situation with SHORTLY-PRECEDE( $t_1, t_2$ ) or NEARLY-EQUAL

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 $(t_1,t_2)$ .<sup>1</sup> Moreover, temporal adverbs may not have the same syntactic behaviour even though they are classified into the same subclass. For instance, the ST-related adverbs *cong* 從, *conglai* 從來, *zhijin* 至今, *xianglai* 向來, *sulai* 素來, *lilai* 歷來, *su* 素, and *yixiang* 一向 are grouped into the same subclass. When they co-occur with the aspect markers *le* 了, *guo* 過, and *zhe* 著, however, *cong*, *conglai*, and *zhijin* are incompatible with *le* and *zhe*; in addition, *xianglai*, *sulai*, *lilai*, *su*, and *yixiang* are incompatible with *le* and *guo*. The reason for the difference in the compatibility of temporal adverbs with aspects will be discussed in the following.

In this paper, based on the application of Smith's proposal for temporal location, we suggest more clear-cut definitions and provide descriptive features for each subclass of temporal adverbs. The descriptive features help us to define temporal relations and to predict the compatibility between temporal adverbs and aspect markers.

### 2. Literature Review and Methodology

To make clear-cut differentiations, time points in the temporal axis and the notion of temporal location proposed by [Smith 1991] will be used here to redefine the temporal relations of the temporal adverbs treated in [Lu and Ma 1999]. We will use the data in the Academia Sinica Balanced Corpus (Sinica Corpus) to analyze Mandarin Chinese temporal adverbs.

Smith [1991] discussed aspectual systems in language. She mentioned that the temporal information in a sentence is located in the time when the situation occurs. Adverbials further specify temporal location. Time is represented as a straight line stretching in both directions from Speech Time. The linear representation is presented in (1):

(1) Time Line [Smith 1991] ------ Speech Time ------Past Present Future

<sup>&</sup>lt;sup>1</sup> The terms SHORTLY-PRECEDE( $t_1, t_2$ ) and NEARLY-EQUAL( $t_1, t_2$ ) were mentioned by Yang and Bateman [2002]. The predicate SHORTLY-PRECEDE( $t_1, t_2$ ) indicates that time point  $t_1$  only shortly precedes time point  $t_2$ . The predicated NEARLY-EQUAL( $t_1, t_2$ ) indicates that time point  $t_1$  lies close to time point  $t_2$ . Applying the terms to the explanation of achievements, we can treat  $t_1$  as Yang and Bateman's  $t_i$ , the event initial time, and as Smith's [1991] I, initial points, and regard  $t_2$  as Yang and Bateman's  $t_f$ , the event finishing time, and as Smith's F, final points. Yang and Bateman's expression for the predicates used to express temporal relations are revised of assertions in [Allen 1984].

Following Reichenbach [1947], to temporally locate all types of sentences, three times are required: Speech Time, Reference Time, and Situation Time. Speech Time (ST) is the center of the temporal system. Reference Time (RT) is the temporal standpoint of a sentence, and, in complex sentences, it is a secondary orientation point. Situation Time (SitT) is the time of the event or state, identified as the interval [I]. To show the temporal location of these three times, Smith [1991] gives example 2a and its time line 2b. In 2b, time 2 is Reference Time, while time 3 is Situation Time:

(2) a. Mary said last Tuesday that she was leaving in 3 days.

btime 2		time 3	time 1		
	last Tuesday	+ 3  days	Speech Time		
	Mayr said	Mary leave			

Mandarin Chinese does not have the grammatical category of tense, so temporal location is expressed directly by adverbials and indirectly through the use of an aspectual viewpoint. Temporal adverbials function as locating adverbials, which are classified as deictic, anaphoric, or referential, according to the type of orientation they take [Smith 1991]. Furthermore, Smith illustrates each situation type and viewpoint type with temporal schemata. Below are the temporal schemata of the Mandarin Chinese aspectual markers *le*, *guo*, and *zhe*, which are represented by symbols I, F, F+1, .... and /:<sup>2</sup>

(3) Temporal schema for the -le perfective [Smith 1991]<sup>3</sup>

I F / / (RVC)

(4) The Mandarin –guo perfective viewpoint [Smith 1991]
 I ....F F+1
 / /

<sup>&</sup>lt;sup>2</sup> I and F indicate initial and final points. F+1 indicates a stage distinct from the final stage. The dots indicate internal stages and the slashes indicate the interval process.

<sup>&</sup>lt;sup>3</sup> RVC is an abbreviation of Resultative Verb Complements.

### (5) The –zhe viewpoint [Smith 1991]

I.....

////<sub>State</sub>

Klein [1994] points out five temporal features and notes TT, TU and TSit. TT, topic time, is the time span to which the speaker's claim on the occasion is confined. TU is the time of utterance, which is the time at which the utterance is made. TSit is the time of the situation, which is the time at which the situation occurs.

In addition to Smith's and Klein's terminology, we can apply the event modules in the MARVS framework proposed by Huang *et al.* [2000] to analyze the temporal relations of temporal adverbs. Event modules are the basic building blocks of the event contour. Five event modules stand alone or in combination; they are Boundary, Punctuality, Process, State, and Stage. The event module Boundary is defined as an event module that can be identified with a temporal point and must be regarded as a whole (including a complete Event). It is adopted in this paper to define the Boundary Point.

Yang and Bateman further discussed the semantic temporal relations of an aspect system and proposed principled semantic conditions for aspect combination. In their opinion, the Chinese aspect system is actually composed of both aspect morphemes (-le, -zhe, -guo4, etc.) and aspect adverbials. The Chinese aspect system has, basically, seventeen simple primary aspect forms. These simple primary aspect forms belong to perfective, imperfective, or future-existing subsystem, according to the semantic properties of individual cases. Some simple primary aspect forms can combine to form an aspect of secondary type if their temporal attributes are in harmony. The temporal relation of the combination is represented graphically by time points  $t_i$ ,  $t_f$ ,  $t_r$ , and  $t_s^4$ .

In this paper, we adopt the terms proposed in the research described above to clarify the temporal relation of each subclass of temporal adverbs listed in [Lu and Ma 1999]. We use the notations ST, RT, ET, BP, Start, and End to define temporal relations. Each, respectively, denotes the speaking time, reference time, event time, boundary point, start point of the event, and end point of the event. The symbols  $\langle , \leq , \text{ and } = , \text{ respectively, indicates priority, inclusion}$  and overlap in temporal location. For instances, the temporal features for *le*, *guo*, and *zhe* are defined as follows in our system and they are compatible with the temporal schemata proposed in [Smith 1991].

<sup>&</sup>lt;sup>4</sup> As the second footnote mentions,  $t_i$  is the event initial time, and  $t_f$  is the event finishing time. The symbols  $t_r$  and  $t_s$  are the reference time and speaking time, respectively.

*le*:  $BP \leq ST$ , which means that the prominent boundary point of the referred event precedes the speaking time;

guo: End<ST, which means that the end point of the referred event precedes the speaking time;

zhe: ET=RT, which means that the referred event time overlaps with the speaking time.

# **3.** Temporal Relations and Compatibility between Temporal Adverbs and Aspects

Temporal adverbs were classified by Lu and Ma into two classes, ST-related adverbs and RT-related adverbs, according to the time point of the situation referred to. ST-related adverbs establish constraints between event time (ET) and speaking time (ST), but RT-related adverbs establish constraints between ET and reference time (RT). For example, the ST-related adverb *cengjing* only denotes events or situations that happen or exist before ST. To be precise, the end points of events occur prior to ST. or example, the sentence *wo shangci cengjing jieshao guo* 我上次曾經介紹過 'I have introduced it last time' is grammatical; however, *\*wo xiaci/mingtien cengjing jieshao guo* 我 \*下次/明天 曾經介紹過 '\*I have introduced it next time/tomorrow' is ungrammatical. The RT-related adverb *yijing* 已經 is used to refer to events that happen or exist before either a certain specific time, an event, or ST. For instance, the sentences *shang libaiwu wo yijing chuguo le* 上禮拜五我已經出國了 'I have gone abroad next Friday' are both grammatical even though *xia libaiwu* is a future specific time.

Lu and Ma divided ST-related adverbs into three subclasses and RT-related adverbs into eighteen subclasses. Three subclasses of ST-related adverbs were subdivided into nine sub-subclasses. Eighteen subclasses of RT-related adverbs were subdivided into thirty sub-subclasses. Checking Sinica Corpus, we find that some of the RT-related adverbs in Lu and Ma's classification behave like ST-related adverbs. Some temporal adverbs denote the order of events and establish constraints only between two ETs. Some temporal adverbs refer to habitual situations, which are not related to temporal relations. Therefore, our classification of temporal adverbs is somewhat different from Lu and Ma's. In this paper, temporal adverbs are divided into four classes according to temporal relations. More detailed subclasses will be introduced in the following sections.

# 3.1 Temporal Relations and Compatibility between ST-related Adverbs and Aspects

In our classification, ST-related adverbs are classified into eleven subclasses. Each subclass is characterized and represented by its temporal features and is assigned one semantic type: Time, Duration, or Frequency. Table 1 shows the temporal features of each subclass.

Temporal Adverbs	Temporal Relation	Semantic Role
cengjing曾經, ceng曾	End <st< td=""><td>time</td></st<>	time
yeyi業已, yejing業經	End≦ST	time
zhongyu終於, bijing畢竟, daodi到底	End≦ST	time
xianxing先行	Start <st< td=""><td>time</td></st<>	time
zaori早日, jizao及早, chenzao趁早	ST <start< td=""><td>time</td></start<>	time
zhongjiang終將, zhongjiu終久, zhonggui終歸,	ST <bp< td=""><td>time</td></bp<>	time
zonggu總歸, bijiang必將, chizao遲早, zaowan早晚		
zhongjiu終究	End≦ST	time
cong從, conglai從來, zhijin至今, xianglai向來,	Start <st< td=""><td>duration</td></st<>	duration
sulai素來, lilai歷來, su素, yixiang一向		
zhan暫, zhanqie暫且, guqie姑且, quanqie權且, qie且	ET=ST	duration
yongyuan永遠, yong永, shizhong始終, zhi直	ET=ST	duration
<i>yidu</i> 一度	BP <st< td=""><td>frequency</td></st<>	frequency

Table 1. Temporal relation and semantic role of each subclass of ST-related adverbs

For instance, *cengjing* and *ceng* are grouped into the same subclass of ST-related adverbs. Since they denote actions or situations that happened or existed before ST, the end points of the situations precede ST. Thus, the temporal relation of *cengjing* and *ceng* is defined as End<ST.

Temporal features not only clearly indicate the relations among these ST-related adverbs but also predict and verify the correctness of the co-occurrences of temporal adverbs and aspectual markers, including *le*, *guo*, and *zhe*, by unifying their temporal features. The temporal features of *le*, *guo*, and *zhe* are BP $\leq$ ST, End<ST, and ET=RT, respectively. If the corpus data shows that a given sentence is grammatical after the combination step, its combination of temporal relation will be in harmony; otherwise, there may be something wrong with the temporal relations or some other essential factors may cause incompatibility. On the other hand, we assume that by detecting harmony in the combination of temporal relations between temporal adverbs and aspects, we can predicate whether a given temporal adverb is compatible with *le*, *guo*, and *zhe*. Here, we will use an example with *cengjing* and *ceng*. The corpus data in the Sinica Corpus show the following combinations of *cengjing* with *le*, *guo*, and *zhe*:

(6) *ceng jing* co-occurs with *le*, *guo*, and *zhe* 

a. 我們的通信曾經給了她很大的快樂

women de tongxin cengjing gei ta henda de kuaile

She had been very happy while we wrote letters each other.

b. 我們曾經提過

women cengjing ti guo we had mentioned before

c. 曾經提著小包袱
 *cengjing ti zhe xiao baofu* ever carried little backpack

The combination of *cengjing* with *le*, *guo*, and *zhe* is grammatical, so we conclude that the temporal relation of *cengjing* is correct and assign the semantic role of time to the subclass of *cengjing* and *ceng*. On the other hand, from the observation of the temporal relations of *le*, *guo*, *zhe*, and *cengjing*, the temporal relation of *cengjing* is compatible with that of *le*, *guo*, and *zhe*, respectively. Thus, before checking the data in the Sinica Corpus, we can predict the that co-occurrence of *cengjing* with *le*, *guo*, and *zhe*, respectively is grammatical. The grammatical sentences in (6) prove that our hypothesis and prediction are correct.

Temporal adverbs classified into the same subclass with the same temporal relation may not have the same syntactic behaviours. For instance, *cong*, *conglai*, *zhijin*, *xianglai*, *sulai*, *lilai*, *su*, and *yixiang* are grouped into the same subclass and assigned the semantic role of duration. The temporal relation of these temporal adverbs is defined as Start<ST. We find, however, that *cong*, *conglai*, and *zhijin* are incompatible with *le* and *zhe*; in addition, *xianglai*, *sulai*, *lilai*, *su*, and *yixiang* are incompatible with *le* and *guo*. Although this subclass of ST-related adverbs has the above temporal relation, their compatibility with aspectual markers is somewhat different. The Sinica Corpus sentences shown below reveal that *cong*, *conglai*, and *zhijin* are usually found in negative sentences. The feature [+NEG] brings about the different syntactic behaviours:

(7) 好像這件事從沒發生過

hoaxing zhejian shicong mei fasheng guo It seems this thing hasn't happened before.

(8) 從來不會逃避*conglai buhui taobi*never evade

# (9) 至今尚未出現在他生命中*zhijin shangwei chuxian zai ta shengming zhong*haven't appeared in his life

Temporal adverbs usually co-occur with aspects. The compatibility of temporal adverbs with aspect markers can verify the correctness of temporal relations. Therefore, we focus on not only temporal feature representations of temporal adverbs and aspects but also the co-relations between temporal adverbs and aspects. Table 2 is the reversion of Table 1 and it shows the compatibility of temporal adverbs with aspects. The asterisks indicate a lack of grammaticality.

Table 2. Temporal relations and compatibility between ST-related adverbs and aspects

Semantic Role	Temporal Adverbs	Temporal Relation	Compatibility with le, guo, and zhe		
time	cengjing曾經, ceng曾	End <st< td=""><td>le guo zhe</td></st<>	le guo zhe		
time	yeyi業已, yejing業經	$End \leq ST$	le guo zhe		
time	zhongyu終於, bijing畢竟, daodi到底	End≦ST	le guo zhe		
time	xianxing先行	Start <st< td=""><td>le guo *zhe</td></st<>	le guo *zhe		
time	<i>zaori</i> 早日, <i>jizao</i> 及早, <i>chenzao</i> 趁早	ST <start< td=""><td>*le *guo *zhe</td></start<>	*le *guo *zhe		
time	zhongjiang終將, zhongjiu終久, zhonggui 終歸, zonggu 總歸, bijiang 必將, chizao 遲早, zaowan早晩	ST <bp< td=""><td>*le *guo *zhe</td></bp<>	*le *guo *zhe		
time	zhongjiu 終究	$End \leq ST$	le guo zhe		
duration	<i>cong</i> 從 (+NEG), <i>conglai</i> 從 來 (+NEG), <i>zhijin</i> 至 今 (+NEG), <i>xianglai</i> 向來, <i>sulai</i> 素來, <i>lilai</i> 歷來, <i>su</i> 素, <i>yixiang</i> 一向	Start <st< td=""><td>+NEG: *<i>le guo *zhe</i> others: *<i>le *guo zhe</i></td></st<>	+NEG: * <i>le guo *zhe</i> others: * <i>le *guo zhe</i>		
duration	zhan暫, zhanqie暫且, guqie姑 且, quanqie權且, qie且	ET=ST	le *guo zhe		
duration	yongyuan 永 遠 , yong 永 , shizhong始終, zhi直	ET=ST	le *guo zhe		
frequency	yidu一度	BP <st< td=""><td>le guo *zhe</td></st<>	le guo *zhe		

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# **3.2 Temporal Relations and Compatibility between RT-related** Adverbs and Aspects

Having adopted the corpus-based approach and analyzed the time points along the temporal axis, we show in Table 3 the sub-classification of RT-related adverbs.

Semantic Role	Temporal Adverbs	Temporal Relation	Compatibility with le, guo, and zhe		
time	yijing已經, yi已, zaoyi早已, zaojiu 早就, dou都	BP <rt< td=""><td>le</td><td>guo zhe</td></rt<>	le	guo zhe	
time	gang剛, ganggang剛剛, cai才	BP≦RT	le	guo zhe	
time	xian先, yuxian預先, shixian事先	$BP \leq RT$	le	guo zhe	
time	jijiang即將, jiangyao將要, jiuyao 就要, kuai快, xingjiang行將	ST <rt<start< td=""><td>*le</td><td>*guo *zhe</td></rt<start<>	*le	*guo *zhe	
time	<i>like</i> 立刻, <i>liji</i> 立即, <i>jike</i> 即刻, <i>mashang</i> 馬上, <i>ganjin</i> 趕緊, <i>gankuai</i> 趕快, <i>ganmang</i> 趕忙, <i>lianmang</i> 連忙, <i>jimang</i> 急忙, <i>jiu</i> 就, <i>bian</i> 便, <i>dangji</i> 當即	RT≦Start	le	*guo zhe	
time	<i>dunshi</i> 頓時, <i>dengshi</i> 登時, <i>shashi</i> 霎時, <i>lishi</i> 立時, <i>yixia</i> ( <i>zi</i> )一下(子)	RT≦Start	le	*guo zhe	
time	<i>turan(jian)</i> 突然(間), <i>zouran</i> 驟然, <i>mengran(jian)</i> 猛然(間), <i>mengdi</i> 猛地, <i>modi</i> 驀地	RT≦Start	le	*guo zhe	
duration	zheng 正, zhengzai正在, zai在	ET=RT	*le	*guo zhe	
duration	hai 還, haishi 還是, reng 仍, rengran仍然, rengjiu仍舊, yiran 依然, yijiu依舊, zhaojiu照舊, zhaoyang照樣, zhaochang照常	BP≦RT	le	guo zhe	

Table 3. Temporal relations and Compatibility between RT-related Adverbs and Aspects

The RT-related adverb *yijing* represents actions or situations that finish, happen or exist before a certain specific time, another action, or a situation. The BP of a situation denoted by *yijing* must precede RT; therefore, its temporal relation is BP<RT. The Sinica Corpus data point *yijing* is compatible with aspect markers.

(10) 一定已經打破了紀錄

*yiding yijing dapo le jilu* have certainly broken the record

- (11) 已經吃過飯yijing chiguo fanhave had a meal
- (12) 蛇已經咬著他了
   she yijing yao zhe ta le
   A snake has bitten him.

We find that the combinations of temporal relations of some classes and those of aspect markers contradict the corpus data. The temporal adverbs classified in subclasses with *like*, *dunshi*, and *turan(jian)* indicate situations or events that happen immediately after ST or another situation. Their temporal relation is defined as  $RT \leq Start$ . The corpus data show that these RT-related adverbs are incompatible with *guo*; however, their temporal relation  $RT \leq Start$  is compatible with *guo*. Sentence (13) shows the temporal relation of *like* between RT and ST:

他一聽到消息,立刻回了電話
 *ta yi tingdao xiaoxi like hui le dianhua* He immediately called back when he got the news.

In sentence (13), RT is *ta yi tingdao xiaoxi*, and ST is the present. The temporal relation of *like* in sentence 13 is defined as RT  $\leq$  Start<ST, which is compatible with the aspect markers *le*, *guo*, and *zhe*. However, the corpus data show that *guo* is not compatible with *like*. The temporal relation RT  $\leq$  Start focuses on the start points of events, while the aspect marker *guo* focuses on subsequent stages following the end points of events. On one hand, an event can be viewed as a whole or as consisting of different parts. When it is viewed as a whole, the temporal relation is defined by BP. When it is viewed as consisting of different parts, its temporal relation is defined by either the start point or end point. Since Start is the focus of the temporal relation RT  $\leq$  Start, the aspect marker *guo* indicating End is incompatible with it. Thus, RT-related adverbs that are assigned to the same subclasses as *like*, *dunshi*, and *turan(jian)* are actually incompatible with *guo* even though their temporal relations seems to be compatible. On the other hadn, the main feature of -guo is that it indicates a discontinuity with the present or other Reference Time [Smith 1991]. The subsequent stage cannot be considered part of the event and is separate from the situation, so the temporal relation of *guo* is not compatible with the temporal relation RT  $\leq$  Start. Thus, *RU* = Start. Thus, *guo* is incompatible with the

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temporal adverbs classified into subclasses with like, dunshi, and turan(jian).

# 3.3 Temporal Relations and Compatibility between ET-related Adverbs and Aspects

In Lu and Ma's classification, some temporal adverbs are neither ST-related adverbs nor RT-related ones. These temporal adverbs establish constraints between two ETs, and denote the order, sequence, or succession of two situations. Thus, we classify these temporal adverbs into another class: ET-related adverbs. Table 4 lists the ET-related adverbs and their feature representations and co-relations with aspects.

Table 4. Temporal relations and compatibility between ET-related adverbs and aspects

Semantic Role	Temporal Adverbs	Temporal Relation	Compatibility with le, guo, and zhe
time	xianhou先後,xiangjyi相繼	$ET_1 \leq ET_2$	le guo zhe
time	<i>tongshi</i> 同時	$ET_1 = ET_2$	le guo zhe
duration	ranhou然後, erhou而後, suihou隨後, suiji隨即, congci從此	$ET_1 \leq ET_2$	le *guo zhe

Since these temporal adverbs refer to the successive of events, their temporal relations have no relation with ST and RT. These temporal adverbs only concern the sequence of events in time.

# **3.4 Feature Representations and Compatibility between other Temporal** Adverbs and Aspects

Some temporal adverbs mark habitual situations or the temporal manner of situations. Habitual situations represent that situations go on without focusing on any time points in the time axis. Temporal adverbs denoting the manner of situations are not related to temporal relations. Consequently, these temporal adverbs are classified into another subclass shown in Table 5.

Semantic Role	Temporal Adverbs	Features	Compatibility with le, guo, and zhe	
frequency	<i>changchang</i> 常常, <i>chang</i> 常, <i>shichang</i> 時常, <i>wangwang</i> 往往, <i>shishi</i> 時時, <i>shike</i> 時刻, <i>bushi</i> 不時, <i>meimei</i> 每每, <i>lao</i> 老, <i>zong</i> 總, <i>yizhi</i> 一直	high frequency *experience	le *guo zhe	
frequency	ouer偶爾, ouer偶而, jianhuo間或, youshi有時	low frequency *experience	le *guo zhe	
time manner	<i>jian</i> 漸, <i>jianjian</i> 漸漸, <i>jianci</i> 漸次, <i>zhujian</i> 逐 漸, <i>rijian</i> 日漸, <i>rijian</i> 日見, <i>zhubu</i> 逐步	slow stage change *experience	le *guo zhe	

 Table 5. Feature representations and compatibility between other temporal adverbs and aspects

time	<i>suishi</i> 隨時	preparatory	*le	*guo	zhe
manner					
time	anshi按時, anqi按期	preparatory	*le	*guo	*zhe
manner		regular			

### 4. Conclusion

In sections 3-1 to 3-4, we classified the temporal adverbs listed by Lu and Ma into four main classes. The subclasses in each main class are somewhat different from Lu and Ma's although the majority are similar. Lu and Ma's two-class classification of temporal adverbs is vague, so we adopt four more detailed classes. The corpus data in the Sinica Corpus verify the correctness of our temporal relations. In addition, the co-relations of temporal relations between temporal adverbs and the aspect markers *le*, *guo*, and *zhe* help us to predict the co-occurrences of temporal adverbs with aspect markers. The feature representations of temporal relations of temporal relations are also helpful for assigning semantic roles to temporal adverbs in the Sinica Treebank.

In future work, if necessary or for other reasons, the subclasses of temporal adverbs may be subdivided into sub-subclasses. Furthermore, certain classes of temporal adverbs can co-occur grammatically, while certain classes cannot.

- 他曾先行離去
   *ta ceng xianxing liqu* He had left in advance.
- (15) \*他曾早日離去
   ta ceng zaori liqu
   He had left soon.

In sentence (14), the temporal adverb *xianxing* co-occurs grammatically with *ceng*; however, in sentence (15), *zaori* cannot co-occur grammatically with *ceng*. Temporal relations or other linguistic factors causing such differences in compatibility are worth investigating. In addition, the RT-related adverbs may be temporal points, temporal durations, or event times, as in '*ta yi tingdao xiaoxi*' in sentence (13). The reference of RT-related adverbs may be further investigated.

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