Deriving Output Probabilities in Child Mandarin from a Dual-Optimization Grammar[*]

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Abstract

We examine the patterns of optionality that are characteristic of the acquisition of two Mandarin Chinese sentence-final temporal/aspectual markers: inchoative *le* and progressive *ne*. What we observe is a productive and systematic pattern of optionality (two forms *ne* and *le* for one meaning: inchoative) and ambiguity (one form *ne* for two meanings: progressive and inchoative) in spontaneous production by three children acquiring Mandarin. We analyze the overuse of *ne* in child Mandarin as a retreat to a default form that results from an impoverished syntactic representation.

We propose an Optimality-Theoretic account in which constraints requiring syntactic realization of the features of the intended meaning "float" in the ranking over constraints that require economy of syntactic structure. These partial rankings characterize a set of alternative grammars that the child uses in production.

We propose a Dual-Optimization solution to explain the gap between the children's production and comprehension of inchoative S-*le* and progressive *ne*.

I. Introduction

It is well known that children at the earliest stages of acquiring syntax show optionality in forms. To take only one example, in many languages children around the age of 2 produce both adult-like inflected verbal forms (e.g. *he goes*) and non-finite root forms (e.g. *he go*) in main clauses at the so-called 'Optional Infinitive' stage (Wexler, 1998).

In this paper, we examine the patterns of optionality that are characteristic of the acquisition of two Mandarin Chinese sentence-final temporal/aspectual markers: inchoative *le* and progressive *ne.* What we observe is a productive and systematic pattern of optionality (two forms *ne* and *le* for one meaning: inchoative) and ambiguity (one form *ne* for two meanings: progressive and inchoative) in spontaneous production by three children acquiring Mandarin. Specifically, young speakers around the age of 2 frequently use *ne* (incorrectly) to express inchoative aspect. That is, they substitute a default form for the target adult form resulting in a pattern that can naturally be formalized through Distributed Morphology (Halle & Marantz, 1993) and Optimality Theory (Prince & Smolensky, 1993/2002).

The bulk of our study focuses on providing a formal model of the stages of acquisition of these two markers. The basic observation is that from stage to stage (determined by an independent measure, Predominant Length of Utterance or PLU; Vainikka, Legendre & Todorova, 1999) the proportions of inchoative *le* and progressive *ne* in the children's utterances do not increase discretely, but rather continuously. We argue for a partial ranking analysis (see, e.g. Anttila, 1997; Boersma & Hayes, 2001; Legendre, Hagstrom, Vainikka, & Todorova, 2002; Reynolds, 1994) that pits structural

realization of temporal/aspectual features against a hierarchy of constraints demanding economy of syntactic structure. Partial constraint rankings determine sets of strict rankings, each of which can yield a potentially different optimal output.

The partial ranking analysis entails that children entertain multiple grammars on the production side of acquisition. In the coexisting child grammars at the earliest stage, taken together, inchoative aspect specifically maps onto both *le* and *ne*. The present study formalizes the notion of default as a form resulting from the relative ranking of faithfulness and economy constraints.

We further consider the Mandarin children's error-prone production in light of what preliminarily appears to be perfect comprehension of adult *ne* and *le.* Bearing in mind that the comprehension evidence derivable from the study of a production data corpus is more suggestive than conclusive, we propose a Dual-Optimization analysis whereby optimization running in the two directions specified by a given constraint ranking (i.e. from input interpretation to surface expression for production and in reverse from input expression to interpretation for comprehension) yields imperfect production and at the same time perfect comprehension. This result supports the Dual-Optimization proposal of Smolensky (1996b) and in fact extends it to partial ranking grammars, which were not considered in the original proposal.

To the extent that the present analysis is successful in capturing the type and amount of variation displayed by young learners of Mandarin, we have additional evidence for partial constraint rankings as a means for explaining variation. Furthermore, the proposed analysis of Mandarin children's production/comprehension patterns argues in favor of Dual Optimization and against several alternative models of Bidirectional

Optimization (e.g., Blutner, 2000; Wilson, 2001; Zeevat, 2000) in the domain of developing grammars.

The paper is organized as follows. Section 2 introduces the Mandarin temporal/aspectual markers and lays out a set of two morphological realization rules that bridge the syntactic analysis of temporal/aspectual markers with their surface form. Section 3 is a detailed discussion of the stages of acquisition as shown in production by three Mandarin speakers, in particular the changing proportions of errors through the course of development. This discussion leads to construing *ne* as a default temporal/aspectual marker, a formal analysis of which is developed in Section 4. One main feature of the formal analysis is that a quantitative analysis of variation is naturally derived from the partial constraint ranking version of OT. In Section 5 we turn to a preliminary examination of children's comprehension of *ne* and *le* which favors a Dual Optimization approach over a Bidirectional Optimization as a model of production/comprehension. Section 6 summarizes the results of the paper.

2. Mandarin Chinese Tense/Aspect

While all languages encode temporal/aspectual properties of events, they differ with respect to which properties are grammaticalized and how these properties are expressed. Traditionally, Mandarin particles have been taken to encode aspectual distinctions such as perfective, inchoative, or progressive (Li & Thompson, 1981; Li, 1990) but the precise classification of these particles has been the subject of some debate.

The literature to date has concentrated on six such markers in Mandarin, verb final *le* (V-*le*), sentence final *le* (S-*le*), *ne*, *zhe*, *zai*, and *guo*. A brief elaboration on the

meaning of these markers follows below, including both examples from the literature and from the child data we examined. The child data we examine was originally collected by Tardif (1993, 1996) and contributed to CHILDES (MacWhinney & Snow, 1985).

Following Chan (1980), Chao (1968), and Sybesma (2001) (but contra Li, 1990) we distinguish two *le*s, each encoding different temporal/aspectual properties and allowed to co-occur, in distinct syntactic positions. S-*le*, often called an inchoative marker, emphasizes the inception of a situation (Chan, 1980:52–3), implying that the situation did not hold prior, and indicates a relevance of that situation to the moment of current concern (Li & Thompson, 1981:240–290; Sybesma, 2001:60–2).[1] S-*le* is the focus of the present study. Examples from child-directed speech are indicated as 'A-to-CH'.[2]

(1) (a) wǒ míngbái nèi-jiàn shì **le**.
I understand that-cl thing le
'Now I understand it' (Sybesma 2001:60)

(b) wǒ bù xiǎng mǎi nèi-běn shū **le**.
I not want buy that-cl book le
'I don't want to buy that book anymore' (Sybesma, 2001:60)

(c) bú huà **le**!
Neg draw le
'(We/Let's) stop drawing now.' (A-to-CH: BBvis5)

The homophonous V-*le* is a perfective marker, indicating the termination of a bounded event, temporally, spatially or conceptually (Chan, 1980:47; Chao, 1968:246; Li & Thompson, 1981:185).

(2) (a) hái mǎi le yí-ge dà qìqiú.
in.addition buy le one-cl big balloon
'(Your mom) also bought a big balloon.' (A–to-CH: YYvis1)

(b) Dǎ - bài -**le** zhàng le.
Fight lose-le battle le
'You lost your battle.' (A-to-CH: YYvis6)

It is worth pointing out that in a sentence with an intransitive verb (hence, in many child utterances), the same morpheme *le* meets both descriptive criteria, being both postverbal and at the end of the utterance (3). In such cases, -*le* can be interpreted as either S-*le* or V-*le* (or even both simultaneously; cf. Chao, 1968).

(3) Tā lái **le**.
he come le
'He has come' *or* 'He is coming' (Sybesma, 2001:65)

Ne is a sentence-final progressive marker. *Ne* suggests the continuation of the process around the reference time. It often co-occurs with the preverbal *zai* with process

verbs, or with postverbal *zhe* with transitory states, both of which themselves contribute a similar durative/progressive meaning. For permanent states, *ne* occurs alone or with *hai* 'still' (Chan, 1980:61–65).

(4) (a) Tā **zài** jiǎng gùshì **ne**.
3sg zai tell story ne
'He is telling a story.' (Chan 1980:65)

(b) Tā (hái) méiyou kànwán zhèiběn shū **ne**.
3sg (still) not read this-cl book ne
'He (still) hasn't finished reading this book (yet).' (Chan 1980:64)

(c) Yángyang nǐ xīn-lǐ **zài** xiǎng shénme **ne**?
YangYang 2sg heart-in zai think what ne
'What are you thinking about, Yangyang?' (A-to-CH: YYvis1)

Both *le* and *ne* are productively used by 2-year-olds acquiring Mandarin Chinese. With respect to coding, however, the homophony of V-*le* and S-*le* complicates the analysis of the corpus somewhat; there are cases in which it is very difficult to know for certain which was intended by the child. We opted for a conservative strategy by excluding all truly ambiguous instances of *le*. We return to coding issues later.

For the sake of completeness we mention the other aspectual markers, *zhe* and *guo*, although they are quite rare in 2-year-old child speech. *Zhe* is a postverbal durative

marker. *Zhe* suggests durativity of a state (Chan, 1980:65), or an on-going posture or physical disposition (Li & Thompson, 1981:221).

(5) (a) Tā chuān-**zhe** píxié.

3sg wear- zhe leather-shoe

'S/He is wearing his/her leather shoes.' (Li & Thompson, 1981:221)

(b) zài jiā dāi-**zhe** yǒu shénme jìn ne?

at home stay-zhe have what fun Q

'What fun is staying at home?' (A-to-CH: YYvis1)

Guo occurs postverbally and marks indefinite past aspect or past experience. *Guo* suggests something "happened at least once in the past—ever" (Chao, 1968:251).

(6) (a) Nǐ chī-**guò** yúchì méiyou?

2sg eat-guo fish-fin Neg

Have you ever eaten shark's fin? (Chao, 1968:251)

(b) du méi jiàn-**guò** shì-bú-shì a ?

all Neg see-guo be-Neg-be Q

'(We) haven't seen (any of these types of cars) before, right?' (A-to-CH: HYvis1)

Mandarin particles have traditionally been assumed to encode aspectual distinctions but not tense (e.g. Smith, 1991; Erbaugh, 1992). Instead, event time is expressed by means of time adverbials like 'yesterday,' 'later,' etc. Recent studies however have pointed out that some of these 'aspectual' particles do not merely or even primarily mark grammatical aspect. For example, Sybesma (1997) argues that S-*le* functions in the same way as tense, having a deictic function that anchors a specific event to a particular point on the time axis. Zhang (2000) uses distributional patterns to argue that *ne*, like S-*le*, should be considered to realize tense, structurally higher than the non-deictic (less controversially aspectual) markers like V-*le*, postverbal *guo,* and *zhe*. See also Chiu (1993).[3]

For our purposes, we need not enter the debate as to the proper characterization of the semantic contribution of these temporal/aspectual particles; we need only the conclusion that these morphemes (*ne*, S-*le* vs. *guo*, *zhe*, V-*le*) occupy *distinct* structural positions, taken (following Pollock (1989) and much subsequent literature) to be the realizations of separate functional projections, both of which occur structurally below the projection housing interrogative particles (CP). Following Sybesma (1997) and Zhang (2000), we posit two functional projections, which we label TP (for S-*le* and *ne*) and AspP (for V-*le*, *guo*, and *zhe*).

Ne is characterized as having a broad function in Chan (1980). Unlike imperfective *zai* and *zhe*, *ne* may co-occur with states and processes. We interpret this to indicate that S-*le* is a more specific T morpheme than *ne*. S-*le* realizes a T feature which we will simply call [incept], without any further attempt at its precise meaning; mnemonically, [incept] suggests the employment of the deictic temporal reference point

to mark an event's inception. The presence of this feature is not expressed by *ne*, however: *ne* is an unmarked or *default* realization of T, in which no event inception is linked to the temporal reference point; this reference time is not typically a boundary point of an event but rather a time of event continuation, as in the progressive. We will simply use [T] to indicate this unmarked tense feature.

The realization of the two functional heads T and Asp can be formalized in the vocabulary of Distributed Morphology (Halle & Marantz, 1993) as follows:

(7) Relevant morphological realization rules

(a) *le* ⇔ T [incept] / in env. Asp

(b) *ne* ⇔ T

The Asp node of a syntactic structure will be spelled out, depending on its content, as *zhe*, *guo*, *le*, or Ø, with Ø expressing inchoative. According to (7a), T is spelled out as *le* only when it bears the [incept] feature and an AspP is present in the structure (we might at least informally think of this as a requirement that the event referred to by the sentence is bounded in a way that allows reference to at least one endpoint). Otherwise—if either T lacks the [incept] feature or Asp is missing—T is spelled out as *ne*, in accord with (7b).[4]

To foreshadow our analysis, we will adopt the view that syntactic representations in child speech, when they differ from adult representations, might lack one or both of the TP and AspP projections (cf. Legendre et al., 2002; Radford, 1990; Vainikka 1993/4; etc.). According to the proposal in (7), in Mandarin, if the AspP projection is missing, the

default pronunciation of T, *ne*, will result; only if both TP and AspP are present can the morpheme *le* appear.

In section 4 we show how incorporating this syntactic representation of Asp and T to an optimality-theoretic analysis of development stages yields novel insight into the course of acquisition.

3. Stages of acquisition of *le* and *ne*

It is impossible to explain the course of acquisition over several stages without an adequate and explicit characterization of the notion of developmental stage. To this end, we make use of a metric developed in Vainikka et al. (1999) that formalizes and links two traditional observations about language development. The first is that children go through a one-word stage, a two-word stage, etc.; the other is that the appearance of verbs marks an important milestone in the acquisition of language. The Predominant Length of Utterance (PLU) is a metric that takes into account both the relative length of the child utterances and the proportion of verbal utterances. It was developed as an alternative to the Mean Length of Utterance (MLU; Brown, 1973). Although very commonly used in the acquisition literature, the MLU has proven to be an unreliable means of measuring a child's syntactic development (see, e.g., Klee & Fitzgerald 1985). Vainikka et al. (1999) provide significant cross-linguistic evidence that a change in PLU stage corresponds to specific syntactic developments in individual languages. Moreover, the PLU metric has been instrumental to detailed analyses of acquisition of tense and person agreement in French and Catalan (Legendre et al. 2002; Davidson & Legendre, in press).

The PLU stages which occur in Tardif's early Mandarin transcripts are 3b and 4b. The relevant definitions for these stages are given in Table 1.

Insert Table 1 here

The guidelines developed for determining PLU stages in Mandarin combine the original PLU guidelines (Vainikka et al. 1999) with Tardif's (1993) guidelines for determining MLU in Mandarin; specific details are given in Appendix 1. We examined transcripts of three Mandarin speaking children from the CHILDES database (MacWhinney & Snow, 1985). These data were collected in Beijing by Tardif (1993, 1996) from firstborn only children whose parents were both native speakers of Mandarin with at least a college education.

Our study focused specifically on the children's use of S-*le* (inchoative), and errors made where S-*le* would be expected in the corresponding adult utterances. We found only one unambiguous instance of V-*le* (that was not simultaneously an S-*le* according to the meaning) produced by one child (YY, file 5). We do not present figures for the production of experiential *guo*, durative *zhe*, or progressive *zai* here since the children only used these forms rarely, if at all.

Our counts included the colloquial Beijing variants *na* and *la* (a phonological merger of *ne-a* or *le-a, a* being an interjection (Ding, Lu, Li, Sun, Guan, Fu, Huang, & Chen (1979)). First, two native speakers/co-authors evaluated all instances of *le, la* and *ne, na* in the child speech and in the adult speech and categorized each instance into one of the groups listed in Table 2. A third native speaker not connected to the research

project was recruited to independently recode a randomly selected sample of the children's data (BB's vis1, 287 utterances) using the same coding guidelines. Since the independent categorization was found to be in agreement with that conducted by our original two speakers except for one form,[5] we conclude that the original coding was not biased in favor of our analysis. Further details on our coding procedures are outlined in Appendix 2. All *le*s that were clearly interpretable as emphasizing the beginning of a new situation, even in the absence of an object, were included. See Table 2 for details on coding decisions.

Insert Table 2 here

We coded the first and last visits of BaoBao (male), YangYang (male). We coded the first and fourth visit from BingBing (female) from this corpus (Table 3).[6]

Insert Table 3 here

In Tables 4, 5, and 6, we give these counts as a proportion of the child's total number of utterances containing a verb, compared to the corresponding proportion derived from the child-directed adult utterances in the same transcript.[7] We take the adult proportion to be the target, which, for example, these three children appear to have attained for S-*le* at stage 4b (see Section 4.2).

Because the children are very young and often produce few tokens, especially at the earliest stage, tests of statistical significance are included in Tables 4–6 and further discussed below.

Insert Tables 4-6 here

We used a two-tailed Fisher's exact test to calculate the statistical significance of the differences between the child and adult productions of each form at each stage.[8] This enabled us to identify the developmental pattern outlined below. First, the children's production of S-*le* starts off noticeably lower than that of their adult counterpart. For example, at the earlier stage, BB produces a quarter as many S-*le* forms as his adult counterpart (4.9% vs. 20.3%), as does LXB (6.3% vs. 27.5%); this difference is significant ($p < 0.001$), as are the differences in production of *S-le* between LXB and YY and their respective adult counterparts ($p < 0.0001$ for each.). In contrast, the difference between the child and adult productions is no longer significant by the time the children reach stage 4b ($p < 0.7$, 0.1, and 1, for BB, YY, and LXB vs. adult). Overall then, the children significantly under-produce S-*le* at stage 3b, compared to their adult interlocutors.

Though productions of perfective *V-le* and progressive *ne* are not the primary focus in this paper, some notable patterns emerge as well from Tables 4–6. Children fail to use perfective aspect (V-*le*; (2b)) during both stages. Only one child-produced *V-le* was found in all six files. Since the proportions in adult speech are already low, the difference is not statistically significant. Our observation, however, accords well with

Erbaugh (1992): Based on a study of four young monolingual Mandarin speakers from Taiwan, she reports that all instances of *le* below MLU 2;5/age 2;4 are both verb-final and sentence-final. There is not a single instance of a 'V-*le* X' sequence among the 2,300 *le*'s in her 64 hour-long corpus.

Overall, the data analysis suggests that children overproduce *ne* at the earlier stage in relation to the adults. YY's proportion of utterances with verbs containing *ne* is significantly higher than that of his adult counterpart ($p < 0.01$). The difference between BB's proportion and his adult counterpart's almost reaches statistical significance ($p < 0.1$). Though the difference is not significant between LXB and her adult counterpart, the relative productions of *ne* still follow the trend of the other children in that her production of *ne* is higher than that found in adults.

Our interpretation of the children's overproduction of *ne* is that in the large majority of cases, *ne* serves as the default temporal/aspectual marker, according to (7b); mostly, it appears in place of an intended inchoative S-*le*. In support of the view of *ne* as a default, we found several unambiguous cases in which *ne* appeared in place of S-*le* in our corpus (we also found no cases where *le* was erroneously used for progressive *ne*, although the opportunities for such errors are rare given the low target rate of *ne* structures). The example below is representative of the instances of *ne* substitutions that are tallied below in Table 7.

(8) CH-to-A: dào -le zàn [: zhàn][9] *ne.

arrive-le stop ne

'(Mickey/The bus) has arrived at the (bus)stop.' (YYvis6)

Parents' corrections in their responses provide further evidence of production errors.

(9) CH-to-A : bú dài ne.
Neg wear ne
'(I) don't (want to) wear it anymore.'
A-to-CH: bú dài le.
Neg wear le
'(You) don't (have to) wear it anymore.' (BBvis1)

Moreover, the frequency of 'inchoative *ne'* is inversely related to the correct S-*le* forms over the course of development (see Figures 1 and 2).

Even considering only utterances where *ne* seemed to be appropriate from the perspective of the adult grammar (as in (4c)), we seem to see an overproduction of *ne*. The children at the early stages are using *ne* quite a bit more often than adults do. A preliminary scan of the child data indicates that at the same time, children are using *zhe* (also used in sentences with progressive meaning) quite a bit less often than adults. This suggests that *ne* may be serving as a default marker not only for S-*le* but also in utterances that would have contained *zhe* if generated by the adult grammar, although this remains at the level of speculation, pending further systematic study. This accords well with the observation that adult *ne* has quite a broad function, covering the meanings of progressive *zai* and durative *zhe*, as well as being a question marker and emphatic marker in the spoken Beijing dialect (Chan, 1980).

We adopt the view that the children use *ne* as a default temporal/aspectual marker, but we will briefly outline our reasons for believing that the child usage of *ne* does not simply arise from some form of imitation of the adult input. That is, it does not seem likely to us that child productions of V+*ne* for some particular verb V arise merely as repetitions of adult forms V+*ne* with that specific verb.

It is clear from the underproduction of S-*le* and the overproduction of *ne* that the children are not simply imitating the frequencies they hear in the input. An examination of the range of verbs that children and adults use with *le* and *ne* provides further evidence that the pattern is productive, and not an imitation of memorized verb-particle combinations.[10] Obviously, there will be some overlap between the verbs used by toddlers and adults in a context of natural interaction. Moreover, the number of verb types is expected to be low, given that the children are not even 2 year old (range: 1;9–1;10 at PLU stage 3b). We examine the data from the three children separately.

Of the 2 verbs LXB (vis1; stage 3b) produces correctly with progressive *ne*, one is used by an adult with *le*, but not with *ne*; the other is not used by any adult in the entire file with either *le* or *ne*. LXB produces a total of 5 verbs incorrectly marked with *ne*. Of these, 4 are used by adults with *le*, and none are used by adults with *ne*. Finally, LXB produces 4 instances of verb + *ne* (2 verb types) that are ambiguous, where it is unclear whether the child intends *ne* or *le*. Both verbs are used with *le* by adults after the child has used them; neither is used with *ne*.

The imitation hypothesis is disconfirmed by LXB's data. She produces verbs marked with *ne* that were not used previously in the file with *ne* or at all by her adult

interlocutors. Results are inconclusive regarding the default hypothesis because the adults do not make productive use of the same verb with *le* and *ne* in different contexts.

YY (vis1; stage 3b) produces 19 verb types in verb+asp combinations, including 4 progressive and 12 inchoative verb+*ne* combinations. Of the 4 progressive verb+ne combinations, 3 verbs are used with *le* by adults and 1 is used with both *ne* and *le* by adults. Of the 12 non-adult-like verb+*ne* combinations 10 verbs are used with *le* by adults and 2 are used with both *ne* and *le* by adults. Overall, YY's pattern is precisely the kind predicted by the default hypothesis. In (10) we illustrate his use of both *ne* and *le* with the same verb meaning 'want'.

The context is the following: Before YY's mother returns home, the babysitter wants to take YY outside to wait for his mother. But YY is deeply involved in riding his toy horse and does not want to go. So the babysitter asks if YY doesn't want his mom any more. YY first response is: *shì de:* 'correct'. The babysitter then asks 'really?' to which YY responds with the full sentence (10a*)* 'I don't want my mother now' confirming his previous answer. When YY's mother returns home a couple of minutes later, the babysitter tells the child 'YY's mother has come back.' Immediately upon hearing that, YY quickly says (10b) 'I want my mother now'. YY uses the same verb *yao:* 'want', once with an adult-like S-*le* and once with *ne*, which an adult would not use in this particular conversational context.

(10) (a). CH-to-A: bú yào m_ma *le*.
Neg want Mom le:
'(I) don't want my mom now.'

(b) CH-to-A: w_ yào m_ma *ne*.
1sg want mom le
'Now I want my mom.'

We may also probe for a relationship between adult production of verb and tense/aspect markers in general and child production of verb + tense/aspect combinations. BB (vis1; stage 3b) produces 10 types and 11 tokens of verbs in combination with a tense/aspect marker. Though all 10 types were used by the adults within the span of the file, four of the types and five of the tokens were introduced in the conversation by BB. Those five tokens appeared in verb(s) + tense/aspect combinations which the adults did not produce. Two out of 11 tokens were replications of an immediately proceeding adult verb + tense/aspect combination. One of these, however, was a contradiction to the adult's utterance, suggesting the child was not mimicking the adult. Lastly, one verb was used in combination with a tense/aspect marker only by the child. Four of the child's verb + tense/aspect combinations were produced by adults only after the child had already produced that same combination.

Lastly, the children produce verb + *ne* combinations that are ungrammatical in adult speech regardless of context. For example, LXB used a *diao* + *ne* 'fall + progressive' combination, a form that would not have been in the child's input. YY used *ne* in combination with several verb compounds indicating the completion of an action (those with direction or result complements), which, again, adults would be very unlikely to have produced. This suggests that the child creates novel forms on his/her own and that the verbs were not memorized with the *ne/le* attached.

To get an estimate of how often the default *ne* is appearing in error, we started by computing the overall average adult proportion of S-*le*; this *target percentage* was 22.5% (514/2281) of verbal utterances. Making the assumption that children's intentions do not develop (discussed in more detail below in section 4.2), we then computed the number of times that the child *attempted* to use S-*le* (22.5% of the child's verbal utterances) and compared this number to the number of S-*le*s and S-*ne*s we actually observed in the child data. These figures are reported in Table 7.

Insert Table 7 here

So, for example, BB–3b produced 81 verbal utterances, and if 22.5% of those were attempted S-*le*'s, we would have expected to see 18 (actually 18.2, on average). We observed 4, indicating that 14 of BB's attempts yielded something other than S-*le*: BB–3b was successful only 4/18.2 = 21.9% of the time in producing S-*le*. Twice (of 18.2 attempts, 11% of the time), we find BB–3b producing *ne* with a (non-adult) inchoative meaning. Given these, we arrive at the percentage of attempts still unaccounted for (100%–22%–11%=67%), which are putative attempts to use inchoative meaning but without any overt reflex. These, we list as 'other errors.'

Figures 1–3 summarize the observed data graphically. Figure 1 displays the children's (adult-like) production of inchoative S-*le.* The pattern is the same for the three children: at stage 3b they produce very few S-*le*s*;* by stage 4b, they reach an adult-like level of production. See Tables 4–6 for exact numbers.

Insert Figures 1–3 here

Not surprisingly the children's use of non-adult-like "inchoative *ne*" decreases over the two stages of development, as do their omission errors.

The use of a default, like *ne*, appears elsewhere in the early acquisition of Mandarin as well. One example is the distribution of negative particles in the three children's speech, which follows a pattern similar to that of *ne*. Mandarin has three negative particles, *bu* (for use with non-perfective verbs), *mei* or *meiyou* (which negates past events but cannot occur with *le*), and *bei* (with imperatives).

(11) CH-to-A : bú dài ne.
Neg wear ne
'(I) don't (want to) wear it anymore.' (Bbvis1).

CH-to-A: t_ méi k_.
It Neg cry
'It didn't cry.' (YYvis6).

A-to-CH: bié f_f_ng le.
Don't act-crazy le
'Stop acting crazy' (Bbvis1)

The negative markers used by the adults in the children's files average 82% *bu*, 8% *mei*, and 10% *bei*. None of the children produces *bei* and their use of *guo* is rare (as mentioned earlier). Hence we would not expect them to frequently produce *mei*. In fact,

they do. For example, BB produces 38% *bu* vs. 62% *mei* at stage 3b. Another child from the Tardif corpus (HY) produces 4% *bu* vs. 96% *mei*. This pattern suggests that *mei* is being used as a default negative marker.

Summing up, the previous discussion has focused on the question of whether the children imitate their adult interlocutors or use *ne* as a default tense/aspect marker. Based on a close examination of verb types used in combination with *le* and *ne* by both adults and children we feel justified in asserting that the pattern of *ne* use by the children is not one of lexically-based adult imitation but one of default usage. The overuse of negative *mei* provides independent evidence for default mechanisms at work in the children's production data.

4. A formal analysis

4.1. General character of the explanation

We propose to explain the course of acquisition in terms of changing outcomes in a competition between two types of conflicting constraints: those requiring expression of intended meaning vs. those requiring minimal syntactic representations. As acquisition proceeds through different stages, the constraints requiring relatively minimal structure become less important than constraints requiring expression of intended meaning (in a specific way, outlined below).

Optimality Theory (Prince & Smolensky, 1993/2002: 'OT') is a framework for formalizing the resolution of constraint conflict in linguistic systems. The grammatical system is given an *input* (an intended meaning), and considers different possible realizations of the input (*output candidates*) with respect to constraints on grammatical

outputs which are ranked by importance (in a language-particular way), choosing the *optimal* candidate expressing the intended meaning by finding the candidate that least violates the constraints, given their relative ranking. Because faithfulness constraints, which require the output to be faithful to the input (that is, to realize distinctions present in the input), often stand in conflict with markedness constraints, which impose certain structural requirements on the output (e.g., minimal structure), their relative ranking is crucial for selecting the optimal candidate.

Language acquisition in an OT model amounts to learning the ranking of constraints in the target language being acquired (Tesar & Smolensky, 2000). As argued by Smolensky (1996a), the initial state (that is, the initial ranking) must be one in which the markedness constraints dominate (out-rank) the faithfulness constraints they potentially conflict with. Under OT as formulated by Prince & Smolensky (1993/2002), the evaluation of candidate output structures for a given input takes place with respect to constraints that are strictly ranked with respect to one another: for any two constraints C_1 and C_2, either C_1 is strictly more important than C_2, written $C_1 >> C_2$, or vice-versa, and no matter how egregious the violation of the lower-ranked constraint would be, it would not justify a violation of the higher-ranked constraint in the optimal candidate.

In light of previous analyses of Child French (Legendre et al., 2002) and Child Catalan (Davidson & Legendre, in press), we make the further assumption that as the child re-ranks constraints, there are points at which several grammars are being entertained.[11] If in the adult language a faithfulness constraint F outranks a markedness constraint M with which it conflicts, the child's ranking may move from the initial state (where M outranks F) to a state in which both rankings are contemplated (either M

outranks F or F outranks M). This is a *partial ranking*, which specifies two different strict rankings, and we can think of F metaphorically as "floating over" M. For each utterance the child produces at such a stage, we assume that one of the currently contemplated grammars is selected essentially at random, which makes a prediction: We should see forms generated by the grammar in which M outranks F (M>>F) with the same frequency as forms generated by the grammar in which F outranks M (F>>M). Where the grammar in which M>>F results in an utterance which is not grammatical in the adult language, this gives us a way to formally model a child producing both adult-like and non-adult-like utterances at the same stage. With more complex partial rankings (e.g., where F floats over several markedness constraints), the frequency predictions become more fine-grained, particularly given that certain output structures will be optimal under more than one possible ranking. This is explored in more detail below with respect to the Mandarin child data.

Based on our first observation—the lack of V-*le* in the child utterances—we propose that the children are compelled to violate the faithfulness constraint requiring overt realization of a [perfective] feature in the input. In the terminology of Prince & Smolensky (1993/2002), this is a failure to parse in the output a feature contained in the input, a violation of one of the PARSE family of faithfulness constraints. This interpretation of the missing V-*le* in child Mandarin mirrors the analysis of missing person agreement in French and tense marking in Catalan put forth in Legendre et al. (2002), Davidson & Legendre (in press). Because realizing the [perfective] feature would entail additional syntactic structure, the lack of V-*le* in child Mandarin indicates that a

constraint prohibiting structure outranks the constraint calling for [perfective] to be realized.

4.2. The Input

One of the underlying assumptions we make in our analysis is that it is not children's intentions that develop, but rather their grammatical system. More perspicuously, we assume that the children will want to say inchoative sentences at roughly the same frequency as adults in the same situations, but as this intention is filtered through the child's grammar at early stages, these distinctions are not always realized in the actual utterance. Translated into OT, this means that the input to a child's grammatical system is the same as it would be for an adult—only the relative ranking of the constraints, which determine how the input will be realized, differ.

Obviously, this assumption is a controversial one. The traditional Piagetian theory is that very young children live in the here-and-now; they are unable to *decenter* or temporally abstract from their present perspective. This prominent view among psychologists has lead to numerous studies claiming that early past-tense markers are aspectual rather than actual tense markers (cf. the Aspect First Hypothesis, Antinucci & Miller, 1976; Bronckart & Sinclair, 1973; Bloom, Lifter, & Hafitz, 1980; etc.). That is, children initially mark completeness rather than a relation between an event time and a reference time, as evidenced by the fact that past tense is predominantly used with achievement verbs (e.g. *break, fall*, etc.) before the age of 2.

A number of detailed studies have challenged the Piagetian theory and the Aspect First Hypothesis. Weist (1989, 1996) argues that children are able to make deictic

temporal references between the age of 1;6 and 2;0 in Polish, i.e. much earlier than previously believed. Similarly, Behrens (2001:450) argues that very young speakers of German between the ages of 1;3 and 1;11 are able to "decenter from the here-and-now and remember past events long before they acquire the tense markers that allow them to encode these meanings." In French, non-present tense is productively used very early on, at PLU stage 3b (Legendre et al., 2002).

With respect to Mandarin, Erbaugh (1982) reports that the four young Taiwanese children she investigated understood that *le* typically co-occurs with past events. Under the age of 2;3 (MLU 1.5-2.5) 85% of their produced *le*s referred to past events (vs. 7% and 8% referring to present and future events, respectively). Out of these 85%, 4% referred to same day and distant past events, 96% referred to immediate past events. (Overall 25% of their verbal utterances refer to the past). Erbaugh (1992:427) further comments: "Typically, the child was the agent of an action in the immediate past. Some 73% of early *le* described the child's own actions. An additional 11% were actions of objects the child was manipulating. And 13% described actions of characters in picture books that the children were pointing to".[12] Even the youngest of her children (1;10) was able to distinguish process and change of state verbs and used *le* correctly for numerous non-punctual process verbs equivalent to '*roll, fly, talk, cry, draw, and play*'. That these children's conceptual command of the temporal and aspectual properties of events reflect the distinctions marked in the adult language is further suggested by the fact that, next to 2,300 *le*'s, Erbaugh's children produced 108 instances of *zai,* 50 instances of *zhe*, and 34 instances of *guo* by the time they reached their third birthday.

In sum, the children from Erbaugh's corpus show evidence of having acquired temporal categories that do not overlap with lexical aspect categories (Vendler, 1967) and of using *le* appropriately, including to "call attention to a noteworthy change of state, such as breaking a cup or finishing a block tower". Her results are all the more interesting because of the method she used to collect the data. Erbaugh apparently had the children taped by a Chinese woman following them with one tape recorder while Erbaugh herself was recording contextual details into a second machine. Further details are missing but it is reasonable to expect that some of her data consist of children monologues while involved in play. The fact that the children used *le* appropriately by themselves presumably reflects their comprehension of *le*.

Beyond temporal and aspectual categories, Erbaugh examined her subjects' pragmatic development and concluded that under the age of 2 they converse very informatively, introduce topics appropriately, and show other evidence of conceptual command of the discourse features present in the adult inputs to the grammar.

4.3. Optimization at PLU Stage 3b

Given our assumption that in the relevant context child and adult inputs are the same, containing whatever features (e.g., [perfective], or [inchoative]) would be appropriate for the adult, we can take the low rate of production for inchoative *le* in child speech as an indication that the children fail to parse the intended [inchoative] feature some percentage of the time. That is, they intend an inchoative utterance but the grammar used (some percentage of the time) to produce the utterance obscures it. For example, in BB's stage 3b, he produces S-*le* approximately 25% as often as his adult counterpart. We

interpret this as a result of BB having a mixture of grammars: some of these grammars rank the constraint requiring the [inchoative] feature to be parsed (realized) above the constraints requiring the structure not to have the additional functional projection needed to parse the [inchoative] feature, while in other grammars these rankings are reversed. For any utterance produced by BB, either grammar may be used; given the specific partial ranking proposed below (see Table 8), this results in the correct form (with S-*le*) being produced 25% of the time, and an incorrect form (without S-*le*) being produced the other 75% of the time.

To formalize our analysis of the Mandarin data, we appeal to the four constraints listed in (12), based on constraints originally motivated for the acquisition of French and Catalan (Legendre et al., 2002; Davidson & Legendre, in press).

(12)

PARSEASP	Aspect features must be realized.
PARSET	Tense features must be realized.
***F**	No functional heads are allowed.
***F^2**	No pairs of functional heads are allowed.

PARSEASP and PARSET are the relevant faithfulness constraints standard in Optimality Theory. *F and *F^2 are part of the Economy of Structure hierarchy for functional projections. Structures with two or more functional projections violate both *F^2 and *F; structures with a single functional projection violate only *F. Because two (or more) functional projections constitutes a more severe violation of Economy of Structure than does a single functional projection, universally *F^2 >> *F; these two

constraints constitute part of a universal subhierarchy of Economy constraints, in which increasing numbers of functional projections violate increasingly high-ranked *F^k constraints (see Legendre et al. (2002) for discussion).

Our analysis focuses on the input underlying an inchoative interpretation; this results in S-*le* for adult Mandarin speakers. In this input, the key tense feature is [incept] while the crucial aspect feature is [inchoative] (recall the analysis based on (7) above). For this input, four candidate output structures are relevant. Figure 4 illustrates these structures, showing the corresponding realizations (following (7)) for the verb *lái* 'to come, arrive'.

Insert Figure 4 here

Candidate (a) is a lexical structure (VP) that violates both faithfulness constraints (PARSEASP; PARSET) and satisfies both Economy of Structure constraints (*F, *F^2). In languages like French and Catalan, such a candidate surfaces as a non-finite form. In Mandarin, the proposal we make immediately below entails that (a) is never optimal for the child transcripts that we analyzed, although it is probable that (a) would have been the output for utterances at an earlier stage. Note that on the surface (a) is indistinguishable from candidate (c): for example, both surface as the verb *lái*. Structure (c) will sometimes be output by the grammars to be proposed.

Candidates (b–d) in Figure 4 contain some degree of functional structure and hence violate (at least) *F. Candidate (b) is a TP structure that satisfies PARSET but violates PARSEASP**.** Given the absence of an AspP in the structure, the morphological

rules in (7) determine that the verb surfaces as *lái ne.* Candidate (c) is an AspP structure lacking a TP projection; this has the opposite faithfulness constraint violation pattern to (b): (c) satisfies PARSEASP but violates PARSET**.** Lacking TP, the rules in (7) don't apply, entailing that in (c) the verb is realized simply as *lái.* Finally, candidate (d) corresponds to the adult structure: with two functional projections, and the feature [incept] on T, by (7) this structure surfaces as *lái le*. Here, both faithfulness constraints are satisfied at the cost of violating both Economy constraints, *F and *F^2.

We propose that at stage 3b (for BB), the faithfulness constraint PARSEASP floats over *F^2 while PARSET floats over both *F^2 and *F. Given that the relative ranking between the structural markedness constraints *F^2 and *F is universally fixed, this yields eight possible rankings; that is, eight grammars are under consideration by the child at this stage. These grammars are listed below in Figure 5. For the inchoative input of interest, each of the eight rankings picks a candidate from those listed above in Figure 4, but a single candidate may be optimal with respect to several different rankings. As displayed in Figure 5, 2 out of 8 grammars yield the adult output *le*; 4 produce a null functional realization (*Ø*) and 2 give *ne.* The proportion of the 8 grammars producing each of the three outcomes is compared to the observed proportions of these forms in Table 8.

Insert Figure 5 here

Insert Table 8 here

The observed frequencies for LXB's stage 3b were qualitatively different, indicating a different partial ranking. The partial ranking we propose for LXB stage 3b is given in Figure 6, along with a comparison of theoretical and observed proportions in Table 9.

Insert Figure 6 here

Insert Table 9 here

In summary, at stage 3b all children produce three alternative forms for an intended inchoative meaning: *le*, *ne*, and *Ø* (no particle). They produce adult-like *le* a quarter of the time, but there is variation among the children with respect to their proportions of non-adult-like forms. BB produces twice as many inchoative *ne*s as *Ø*s, and vice-versa for LXB. Which faithfulness constraint advances first is not something the analysis pre-determines one way or another; either one is theoretically possible and in fact observed.[13] Cross-linguistically we also find differences. French and Catalan, two closely related languages that both mark tense and agreement, differ in this way: French children acquire tense first, while Catalan children do exactly the opposite, acquiring agreement first (see Davidson & Legendre, in press).

Any theoretical model of variation must be flexible enough to allow for such variation and at the same time constrained enough to make verifiable predictions. Our model is constrained in a number of ways:

(a) The constraints relevant to acquisition of Mandarin tense/aspectual markers are universal; they belong to the same family of constraints as those relevant to the acquisition of French and Catalan tense and agreement.

(b) Economy of structure constraints (*F, *F^2) and faithfulness constraints (PARSET, PARSEASP) are arguably present in adult grammars as well (Grimshaw, 1997; Legendre, Smolensky & Wilson, 1998). Typically, Faithfulness constraints dominate economy constraints in mature grammars and thereby allow for the wide range of distinctions that adult language needs to express. The active role of constraints like *F, *F^2 (where they outrank PARSET) is revealed in marked contexts, for example in newspaper-style headlines.

(c) Each evaluation of candidates operates on the basis of a fixed constraint ranking (recall that a child's grammar is not equivalent to a single ranking).

(d) All rankings are equi-probable: for example, any one of the 8 rankings determined by floating constraints at stage 3b has an equal (random) chance of being called on during an evaluation. (Tables 8–9 suggest that there is little evidence against the equi-probability hypothesis, but cf. note 13).

(e) There is no backtracking in floating ranges. For example, once a given constraint range extends to above *F^2 at stage 3b it must extend beyond *F^2 at all later stages of development.

Consider how the no-backtracking constraint on the model affects the development of the young Mandarin speakers. At stage 3b, they produce three alternative forms for an intended inchoative meaning. Where do they go from here? Putting aside a

formal demonstration, which would go beyond the scope of this paper, the model makes three predictions.

(13) Developmental predictions

(a) Once children acquire inchoative *le*, they don't lose it.

After acquiring inchoative *le*:

(b) Once children lose inchoative *ne*, they don't get it back.

(c) Once children stop omitting the inchoative particle, they don't resume omitting it.

What do we observe at 4b? BB produces only *le* and *Ø* while YY and LXB produce only *le* and *ne* (*Ø* is below 5%): see Tables 10 and 11.These are in fact the only two patterns of development predicted possible by (12), short of producing only *le,* which the children haven't mastered by stage 4b. What should happen next, according to (13)? BB should not start producing inchoative *ne*s again (13b). YY and LXB should not go back to omitting an inchoative particle, i.e., producing *Ø*: (13c). Further study is planned to test these predictions.

Before proceeding to the ranking analysis of stage 4b, we need to take into consideration more of the functional-projection Economy of Structure constraint hierarchy introduced in (9). The basic constraint generating this hierarchy is *F; this is violated by a single functional head. The universally-higher-ranked constraint $*F^2$ is in fact the result of *local conjunction* (Smolensky 1993, to appear) of *F with itself: this is

violated when there are two violations of *F in a single extended projection. Similarly, $*F^3$ is the local conjunction of *F with itself three times, and universally $*F^3 >> *F^2$.

(14) **$*F^3$** No triads of functional heads are allowed.

In the adult language, $*F^3$ is violated by any structure which includes a CP projection (and all lower projections)—for example, utterances including a question particle Q such as *ma* in Mandarin. In the earliest stages in our data, the children do not use *ma* or show any other evidence of a CP projection, supporting the interpretation that faithfulness to CP-related PARSE constraints (e.g., PARSEQ) are outranked by $*F^3$. By the time the children acquire an adult-like ranking, however, PARSEASP, PARSET, and PARSEQ must ultimately outrank even $*F^3$.

We can now present partial rankings for stage 4b, which we do in Figures 7–8 and Tables 10–11. As before, the frequency patterns for BB differ from those of the other two children, indicating different partial rankings.

Insert Figure 7 here

Insert Table 10 here

Insert Figure 8 here

Insert Table 11 here

Our analysis can be summarized as follows. Acquisition of temporal/aspectual categories in Mandarin involves the coexistence of grammars at individual stages of development. Some of these grammars yield adult-like utterances, while others yield non-adult-like utterances. The process of acquisition amounts to weeding out the non-adult grammars from the child's "repertoire" by raising faithfulness constraints in the rankings above structural markedness constraints.[14] For grammars in which faithfulness constraints are low-ranked, we see overgeneralization (neutralization of contrast), resulting in an overuse of *ne*.

We close this section by showing graphically a comparison between the observed data and the theoretical account provided by our floating constraint model: see Figures 9–10.

Insert Figure 9 here

Insert Figure 10 here

5. Comprehension vs. production

In the proposed analysis, the ranking of faithfulness constraints in child Mandarin is variable, giving rise to variability in the child's production—here, variation between the single correct adult form and another "default" form. An inchoative interpretation, containing the T feature [incept] and the Asp feature [inchoative], will be expressed correctly as *le* when faithfulness constraints are evaluated sufficiently high in their

floating range, and expressed incorrectly as either *ne* or *Ø* when faithfulness constraints fall in the lower reaches of their ranges.

In production, children are pairing the inchoative intention with all three output forms, *le*, *ne*, and *Ø*, and theoretically it thus seems natural to expect them to do the same in comprehension, i.e., to sometimes incorrectly interpret *ne* (and *Ø*) as inchoative, as well as correctly interpreting inchoative *le*. Empirically, however, it is well known that comprehension normally develops considerably in advance of production (e.g. Bates, Bretherton & Snyder, 1988; Clark & Hecht, 1983; Fraser &, Bellugi, & Brown, 1963). This suggests the hypothesis that children interpret S-*le* as inchoative, and interpret other forms as non-inchoative.

Unfortunately, little evidence bearing on this hypothesis is available at this time. As we discuss below, the transcripts examined offer some suggestions of correct comprehension of the inchoative but no indication of miscomprehension. Any conclusion must of course be regarded as highly tentative pending future work. In the analysis proposed shortly, we provisionally adopt the accurate comprehension hypothesis in order to explore its theoretical implications for the analysis of production developed above. The results prove to shed some light on quite general theoretical issues pertaining to current explorations of formulations of Optimality Theory that combine production- and comprehension-directed optimization.

Insert Table 12 here

The production files do not provide evidence that the children misinterpret *ne*. On the contrary, several file excerpts reveal correct comprehension of both *le* and *ne*. By all indications, in (15) YY seemed to have understood his mother's question about an event that took place earlier in the day.

(15) A-to-CH: j_nti_n yéyé lái ji_ n_ zuò ch_ le ma ?
today Grandpa come pick-up 2sg sit bus le Q
'Did Grandpa pick you up to take a bus today?'

CH-to-A: ji_ *de.
Pick-up particle
'Pick.'

A-to-CH: á:?
ah
'What?'

CH-to-A: ji_ *de *ne.
Pick-up particle le
'(He) picked up.'

A-to-CH: ji_-lái la:?
Pick-up-come la
'(He) came and picked (you) up, right?'

CH-to-A: èm:.
Em
'Yes.' (YYvis1)

(15) illustrates both the child's comprehension of the adult form S-*le*, and the child's pairing of the inchoative with all three forms, *le*, *ne*, and *Ø* in production. The *S-le* in the mother's initial utterance is the only temporal marker indicating that the two activities (pick-up and take the bus) have been completed and they are relevant to the moment of current concern (that YY had some fun with his grandpa prior to the question). YY's affirmative response (cf. his repetition of the verb *jie*) indicates the child comprehended the use of *S-le*. However, in production, the child first used *Ø* to respond to the question, which is ungrammatical in adult grammar. The segment *de* after the verb does not make sense in adult grammar; therefore the mother does not understand his first response and asks "what?" The child responds by adding the inchoative, erroneously produced as default *ne*, which the mother understands but corrects with *la*. YY's final answer is a particle with a falling tone, indicating affirmation.

In (16) YY had been trying to tell his mother that his foot was stuck and he couldn't hug her. He understands his mother's progressive *ne* utterance well enough to continue the conversation by affirming her statement.

(16)	A-to-CH:	ào	bié: zhe	ne,	bù	h_o	q_nrè,	shì	ma?
		Oh,	stuck-zhe	ne	Neg	easy	affection	be	Q
		'Oh, (your foot) is being stuck so it's not easy (for you) to kiss me, right?'							
	CH-to-A:	shì: de							
		Be affirmative							

'Right.' (YYvis1)

Of course, this evidence is merely suggestive. The number of instances like (15–16) is low—but so is the number of adult utterances containing *ne* to start with, as shown in Tables 4–6. The presence of such instances, along with the complete absence of counterexamples, provides preliminary support for the notion of correct comprehension. This is true of all three children.[15]

Let us then provisionally entertain the hypothesis that the children accurately comprehend the inchoative. Now in the account of production proposed in previous sections of this paper, the child's grammar pairs the inchoative with S-*le*, *ne* and Ø-marked forms—yet by hypothesis the child correctly separates them during comprehension. This would count as evidence against the proposed analysis—if this analysis did indeed predict erroneous comprehension. It would then be necessary to account for comprehension and production with separate grammars, or to place the errors of production outside the grammar. Both these options are unattractive, entailing unsatisfactory competence/performance relations. If a grammar is a competence-theoretic characterization of linguistic knowledge that is independent of performance factors associated with use of that knowledge, it is simply incoherent to speak of separate comprehension and production "grammars." If only one of production or comprehension were to reflect the grammar, it would presumably not be production that plays this role, for it would then be necessary to assume that extra-grammatical performance factors are responsible for significantly *improving* performance, enabling adult-like comprehension from a grammar with sub-adult competence, as revealed in production. Rather, if only

one mode of use were to be regarded as reflecting the grammar, it would be comprehension, which must then be adult-like, and the children's erroneous production must result from errors introduced outside the grammar during performance.

This would have unfortunate implications. The first is that there would be imply no such thing as a theory of child *grammar*—and not just in Mandarin tense/aspect marking. In every part of child language where comprehension is far more adult-like than production, the grammar would simply be the adults', and all the phenomena of interest, where child and adult language differ, must be accounted for outside the grammar. All the explanation in vast reaches of child language would need to be carried entirely by the performance theory. The second implication, then, is that any apparently grammatical regularities in child production must essentially be accidental, as it would be only extra-grammatical performance factors that are revealed by production errors. In the current case, it would be an accident that the form overextended by the child is *ne*, the expression of the syntactically less-complex structure (containing one rather than the adult two functional projections needed for S-*le*). By contrast, the analysis proposed in this paper explains child production directly from a grammar admitted by UG, but not yet fully developed; more marked structures are sometimes replaced by less marked structures which are ungrammatical in the adult grammar.

Fortunately, the essentially errorless comprehension of these speakers of child Mandarin is *not* inconsistent with the proposed OT analysis of production—indeed, it is predicted by it. According to OT, the grammatical structure is the best structure—but, we must ask, best *compared to what?* Upon inspection it is clear that the comparison sets are entirely different in production and comprehension. A single OT grammar (ranking) is

indeed a characterization of linguistic knowledge independent of its use: it can be used for either production or comprehension, the different comparison sets in the two uses entailing drastically different consequences of the same knowledge.

In the preceding sections, the grammar of a child Mandarin speaker at one point of development is a partial ranking defined by faithfulness constraints floating over a fixed universal markedness hierarchy enforcing structural economy. This grammar has so far been used in the way that is standard in the OT literature: for production. An input is an intended interpretation I_0, and alternative expressions E_1, E_2, … compete for the title of best expression of I. In comprehension, however, what is given and fixed is not an interpretation but an overt expression. Given such an expression E_0, alternative interpretations I_1, I_2, … compete to be declared the best interpretation of E_0. And crucially, for both competitions, 'best' is defined by the same, single grammar: here, a partial ranking.

According to this natural extension of basic OT, the same child grammar that gives impoverished production generally gives much richer comprehension (Smolensky, 1996b). In brief, the argument is simply this. In production, the competing expressions differ in their degrees of markedness. In child grammars, MARKEDNESS tends to outrank FAITHFULNESS, with the effect that unfaithful but unmarked expressions are optimal. The expressions produced are reduced in markedness relative to the adult's; adult grammars have higher-ranked FAITHFULNESS, forcing more violations of MARKEDNESS. But in comprehension, it is *interpretations* that compete. The adult's expression is given; it generally incurs heavy violations of MARKEDNESS—a degree of violation intolerable for the child's productions—but that makes no difference to the competition. The expression

cannot be changed, cannot be replaced by a less-marked expression, as it would be in production. In comprehension, it is interpretations that compete; the best interpretation is generally the one most faithful to the given expression. This interpretation best-satisfies FAITHFULNESS, and MARKEDNESS is irrelevant because markedness constraints don't evaluate interpretations, only expressions.

This simplified discussion has ignored a dimension of complexity that is generally of considerable interest in syntax: the structure-assignment aspect of interpretation. What is given to the hearer is an *overt* form *O*, and what compete are all structural analyses of *O*, and their associated interpretations. A somewhat subtle illustration in terms of *wh*-chain structures is provided in Smolensky (1996b).[16] But as we now show, in the present analysis the structural alternatives are so transparently related to overt material that the simplified exposition above, in which structure is neglected, actually suffices.

As a concrete example, consider BB in Stage 3b. The partial ranking proposed as the grammar at this stage, given in Figure 5, generates correct *le* as well as incorrect *ne* for the inchoative. Tableau 1 shows one of the total rankings generated by this partial ranking, a total ranking which erroneously produces *ne* as the expression of the inchoative interpretation, [incept], [inchoative]. (This is ranking f in Figure 5).

Insert Tableau 1 here

Recall that according to the proposed realization rules (7), the $TP_{[incept]}$ + $AspP_{[inchoative]}$ configuration is consistently realized with the phonological form *le*,

$TP_{[incept]}$ with *ne*, and $AspP_{[inchoative]}$ with *Ø*. The winning configuration in Tableau 1 is unfaithful $TP_{[incept]}$, realized as *ne*; the adult optimum is faithful $TP_{[incept]}$ +$AspP_{[inchoative}$, *le*. The faithful candidate *a* fails in this child grammar because it violates high-ranking $*F^2$ in virtue of its two functional projections. Among the candidates with only a single functional projection, TP (*b*) is preferred over AspP (*c*) by the ranking PARSET >> PARSEASP.

Given that this ranking expresses the inchoative with *ne*, one might expect that it interprets *ne* as inchoative. But Tableau 2 shows this expectation to be incorrect. The optimal candidate is marked with the arrow ' ➢'.

Insert Tableau 2 here

The markedness constraints $*F^2$ and *F evaluate the *expression*, which is given as *ne*. Since *ne* spells out a single projection TP, *F is violated and $*F^2$ is satisfied. This is true for all competitors, because the expression *ne* = TP is fixed in this competition. Thus these markedness constraints make no distinctions among competitors, and can be ignored. What remains are the faithfulness constraints. These include the PARSE constraints. PARSET is satisfied in candidates *b* and *d* because these interpretations include either the unspecified tense [T] or the tense feature [incept], which is parsed in the expression.[17] PARSET is vacuously satisfied by candidates *a* and *c*: since there is no [T] in these interpretations, there is nothing that PARSET requires to be parsed in the expression. The remaining PARSE constraint, PARSEASP, is similarly vacuously satisfied by *a* and *b*, which contain no Asp feature. But PARSEASP is violated by the other

candidates *a* and *c*: these are interpretations containing [inchoative], which is not parsed in the given expression—*ne* = TP has no Asp head.

At this point the remaining faithfulness constraints become crucial. FILLT requires that if an expression has a T feature, then the interpretation must contain that feature. Similarly, FILLASP requires that an Asp feature in the expression have a corresponding feature in the interpretation. FAITHFULNESS always consists of both PARSE and FILL constraints: the former require that the expression contain enough to express all bits of the interpretation, while the latter require that the expression contain no more. Thus interpretation *c* = [inchoative] violates FILLT because the expression contains a T head but there is no corresponding T feature in the interpretation. (See note 17 concerning the feature borne by T. This feature has been 'epenthesized'—added to the expression with no interpretive feature to license it.) Similarly, the null interpretation Ø violates FILLT: it too provides no T feature to license the TP in the expression being interpreted. But candidate *b* = [T] is perfectly faithful to the expression TP, with no FILL or PARSE violations at all: it is the optimal interpretation. The FILL constraints ensure that *a* and *c* lose to *b* no matter how these constraints are ranked; we can thus take them to be lowest-ranked, as shown in Tableau 2.

Thus Tableau 2 shows that the optimal interpretation of *ne* is the correct one, [T] or 'progressive', not [incept, inchoative] or simply 'inchoative'—even though in production, the inchoative is pronounced *ne* with this same ranking.

That *le* = $TP_{[incept]}$ + $AspP_{[inchoative]}$ is also correctly interpreted is shown in Tableau 3.

Insert Tableau 3 here

Now both markedness constraints *F^2 and *F are violated, since the given expression is TP + AspP which has two functional projections. But as in Tableau 2, these structural economy constraints are irrelevant in comprehension because they do not distinguish between competitors, which are not different expressions but rather different interpretations. The faithfulness constraints PARSET and PARSEASP are both satisfied by all competitors. Regardless of whether an interpretation includes both features (*d*), just one feature (*b* or *c*), or no features (*a*), any features that may be present in the interpretation are parsed in the expression, which includes a projection for both T and Asp. As in Tableau 2, the FILL constraints are decisive, selecting the faithful candidate *d* = [incept], [inchoative]—the correct inchoative interpretation.

Thus on this ranking, *le* is correctly interpreted as inchoative, even though, with the same ranking, the inchoative is produced as *ne*.

The partial ranking under discussion, that of BB in Stage 3b, generates total rankings other than the one considered in the above tableaux. Investigation of the logic of the preceding argument, however, reveals that in this analysis, a total ranking yields correct comprehension regardless of whether that ranking yields correct or errorful production. The variation in production generated by floating FAITHFULNESS does not entail variation in comprehension.

The *Dual Optimization* analysis of production and comprehension deployed here (Smolensky, 1996b) represents one of the earliest proposals for multi-directional optimization in OT: the production 'direction' goes from given interpretation to optimal

expression, while the comprehension 'direction' goes from a given expression to an optimal interpretation. The theory is not a truly bi-directional OT architecture, in the sense of Wilson (2001); in bi-directional optimization, the 'comprehension' (or 'interpretive') optimization conceptually precedes and feeds the 'production' (or 'expressive') optimization: only expressions pre-determined to have the correct interpretation are allowed to compete as the optimal expression of that interpretation. The optimal expression determined by production-directed optimization is constrained by the results of comprehension-directed optimization, unlike the simpler analysis proposed here (e.g. Buchwald, Schwartz, Seidl, & Smolensky 2002, Wilson 2001). Such a bi-directional optimization account could not give the desired results here: the grammatical expression of inchoative could never be *ne*, since *ne* would not be a candidate expression, as it has the wrong interpretation (progressive). Bi-directional optimization cannot capture the pattern of interest here, simple though it is: inchoative is expressed by either *le* or *ne*, but only *le* is interpreted as inchoative.[18]

Similarly, bi-directional OT theories based in 'super-optimality' (e.g. Blutner 2000, Zeevat 2000) cannot account for the present pattern. Such theories characterize a grammatical set of (form, meaning)—i.e., (expression, interpretation)—pairs, requiring that the form be optimal for the meaning and the meaning simultaneously optimal for the form.[19] The pattern of interest cannot be analyzed in any theory in which the language generated by a grammar is a set of (expression, interpretation) pairs, because this omits the crucial *directionality* of the form-meaning relation: (*ne*, inchoative) must be *in* the 'production language' since in expressive optimization, inchoative $\Rightarrow$ *ne*; but (*ne*,

inchoative) must *not* be in the 'comprehension language' since in interpretive optimization, *ne* inchoative.

7. Concluding remarks

In this paper we have provided evidence that the process of acquisition of temporal/aspectual markers by native speakers of Mandarin involves default forms and coexisting grammars: A specific form for a specific functional category appears very early, but it is also frequently replaced by a default form that gradually disappears over time. In Mandarin the only temporal categories present in early speech are the inchoative *le* and the progressive *ne*, the latter also serving as the default form. Other categories appear later, in particular perfective V-*le* and other aspectual markers such as *guo* and *zhe*. Using violable and re-rankable constraints in OT, with partial rankings of those constraints, we arrived at a model that accounts for both variation and frequency of use for the temporal morphology through the course of development.

A second attribute of the present proposal is its correspondence to accounts put forth for French and Catalan functional categories (Legendre et al., 2002; Davidson & Legendre, in press). Acquisition of functional categories (tense, aspect, person agreement) follows the same general course in the three languages via overgeneralization of a default form, independent of the richness of the morphology and the actual default used.

A third attribute is that the conversational nature of the data studied allowed us to compare the children's production with their comprehension of temporal/aspectual markers and make some preliminary claims. While the three children make use of a

default form in production they do not show any signs of having problems understanding their adult counterparts. We explained this acquisition paradox in terms of a Dual Optimization model (Smolensky, 1996b) and in so doing argued against alternative models of Bidirectional Optimization.

To the extent that the present analysis is successful, it enhances our understanding of variation in the context of acquisition and provides support for adopting two widely debated constructs of OT, partial constraint rankings and dual optimization.

APPENDIX 1. Chinese PLU guidelines

Determining PLU stages in a given language involves several steps. First, one must decide what counts as an utterance in that language and what does not. The specific guidelines listed below summarize how the general PLU guidelines were modified into specific guidelines for Mandarin Chinese.

We counted as "utterances" anything that was not a direct repetition, with the exception of responses to questions that an adult would answer with a direct repetition. More specifically:

1. An imitation of a contiguous piece of an adult utterance were not counted as an utterance, except when:
    a. the utterance is a response to a yes-no question (a positive answer is indicated by a direct repetition of at least the verb)
    b. the imitation includes a discontinuity (i.e. a failed direct imitation),
    c. there is a phonological change in the imitation.
2. A self-repetition was not counted as an utterance, except when:
    a. the repetition follows a different utterance made by the child,
    b. the repetition follows an adult utterance which was not ignored by the child,
    b. the repetition is addressed to a different hearer.
3. Syllables that are interjections such as *ou* ('oh'), *em* ,*eng*, or *heng* were never counted as utterances. Included as utterances, however, were words such as *aiyou* (roughly 'oh no!' or 'oops!') that have a more specific meaning, as were question prompts such as *a?*.

4. If the child's repetition either of himself/herself or of an adult is separated from the repeated utterance only by one or more interjections (3), it was considered an immediate repetition and evaluated under (1–2).
5. Unintelligible babble (of the type transcribed in CHILDES as "xxx"), except where such fragments could be confidently coded as interjections (3), were counted as utterances.
6. Sound effects, onomatopoeia, and vocalizations that are clearly not attempts at sentences were not counted as utterances.
7. Non-speech sounds, such as laughing, coughing, or wailing, were not counted as utterances.
8. Rote-learned segments such as portions of songs, nursery rhymes, proverbs, greetings, good-byes, etc., were not included as utterances.

Also important for computing the PLU stage represented by a child transcript is the computation of "words" and "verbs". The following criteria were used for counting these:

1. Stative/qualitative verbs in Mandarin often correspond to adjectives in English. Such words were counted as verbs (based on Erbaugh, 1992; Tardif, 1993), when in the adult language:
   a. the word can be used in the V-not-V construction, and
   b. the word does not need a copula (or other verb marker) to say that something has the property it denotes.

2. Verb forms such as *shuì-shuì* (sleep-sleep), marked by Tardif with an *rv* (resultative verb), were counted as one word.
3. Verbs that take a directional complement, such as *guò-lái* (cross-here) were counted as one word.
4. Phonological fragments were treated as non-transcribed utterances, just like "xxx" would be (Vainikka et al., 1999). If the fragment would have counted as an interjection (see previous criteria, #3), it was treated as a particle and included in the word count unless utterance-initial.
5. Repetitions of a single word in an utterance were not counted as separate words if they are:
   a. stutters
   b. incomplete attempts at a single word

   They were counted, however, if they are repeated for emphasis or appear in different phrasal units.
6. Proper names were counted as a single word (despite often consisting of three units).
7. *Méiyǒu* 'no more' was counted as two words.

APPENDIX 2. Criteria used in coding the *ne* / *le* data

The two native speaker authors developed the following set of criteria for coding the *ne*/*le* data:

1. Sentence-final *le* (S-*le*): Only clear instances of the inchoative *le* were counted. Not all sentence-final *le*'s are counted as S-*le* (since V-*le* can be final with intransitive verbs, e.g., *diào* 'drop', or elliptical expressions, e.g., *xiě le* … 'wrote'). These clear cases are given below.

   a. Where *le* (or *ne*) appears with a stative verb and indicates the inception of a new state (Chan, 1980: 52–3), or the currently relevant state, S-*le* is intended. The example below shows *ne* substituted for an intended S-*le*.

      CH-to-A: nà nà: bǐnggān huài ne. wǒ yào chī zhèige.
      That cookie bad le 1sg want eat this:Cl
      'That cookie has gone bad. I want to eat this one.' (LXBvis6)

   b. When a direct object precedes *le*, it is clearly S-*le*, since perfective V-*le* would precede the object (see 2).

      CH-to-A: guān-shàng mén le .
      close-up door le
      '(I have) closed the door.' (YYvis6)

c. When *le* appears with the negative particle *bu*, it is S-*le*, since V-*le* cannot appear with *bu*.

CH-to-A: zhèi bú yào le.
this neg want le
'(I) don't want this any more.' (LXBvis6)

2. Verb-final (perfective) *le*: V-*le* is clearly indicated when it precedes an object. Note that the following utterance was the only instance of correct V-*le* we found, but it also contains a substitution of *ne* for S-*le*.

CH-to-A: dào le zàn: [: zhàn] *ne:.
arrive le stop le
'(The bus) has arrived at the (bus)stop.' (YYvis6)

3. Inchoative/Perfective *le*: There are instances of *le* that may be interpreted as either V-*le* or as S-*le* in the child data. These were counted as S-*le* in the analysis.

CH-to-A: zhuàng-wán le.
bump-finish le
'(I) finished trashing (the car).' (BBvis5)

4. Errors and ambiguous *le* forms (there were very few tokens, and they were excluded from all counts)

a. Errors: Using *mei* and *le* together, ungrammatical in the adult language.

CH-to-A: méi huà-wán le .
neg draw-finish le
'I have not have not finished drawing yet.' (BBvis5)

b. Ambiguous cases that could have been either *le* or *ne*, based on the response.

CH-to-A: yòu tiào shéngr ne.

again jump rope ne

'It's started to jump rope again now. /

It's jumping rope again now.'

A-to-CH: yòu tiào shéngr le?

again jump rope le

'It has started to jump rope again now?' (LXBvis1)

CH-to-A: téng: ne.

hurt ne (crying)

'It's hurting me. / It's started to hurt me now.'

A-to-CH:téng: le? Huó gāi!

hurt le Serve (you) right

'It's started to hurt you—Serves you right!' (LXBvis1)

5. Progressive *ne*: Only action verbs were counted as exhibiting progressive *ne*. Location verbs with *ne* were not taken to be progressive.

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Table 1. Relevant Predominant Length of Utterance (PLU) stages

Stage number (number of words per utterance):

Stage 3 *"Two word stage"*: Fewer than 60% of utterances are single word utterances and utterances with three or more words do not predominate.

Stage 4 *"Predominantly multi-word stage*": Utterances with three or more words are more common than either one- or two-word utterances.

Secondary stage letter (percentage of utterances with a verb):

Secondary stage b: 60% or fewer utterances contain a verb.

Secondary stage c: More than 60% of utterances contain a verb.

Table 2: Categories into which child utterances were coded

1) Instances of (unambiguous) perfective V-*le*.

2) Instances of inchoative S-*le*. Where S-*le* emphasizes the beginning of a new situation, even in cases where *le* happens also to follow the verb and where the sentence might arguably *also* be perfective (i.e. as if containing V-*le* as well as S-*le*), it was counted as S-*le*. Hagstrom

3) Truly ambiguous instances of *le* (i.e. cases where either an intended *ne* or *le* is appropriate but nothing in the context favors either interpretation) were excluded from our counts.

4) Instances of progressive *ne* that were correctly used.

5) Instances of *ne* that were used where an inchoative S-*le* should have been used.

6) Omissions of S-*le*, counted by one of the native speaker authors. (Credibly identifying omissions is difficult and it is possible that the conservative criteria left some omission errors uncounted.)

Table 3. Subjects from CHILDES Database (MacWhinney & Snow, 1985; originally from Tardif, 1993)

File	Age	PLU	Utterances	Verbal Utterances
BaoBao (BB, male)				
1	1;10.12	3b	287	81
5	2;02.07	4b	706	414
YangYang (YY, male)				
1	1;10.20	3b	269	161
5	2;02.18	4b	278	163
BingBing (LXB, female)				
1	1;09.03	3b	221	126
4	2;01.08	4b	206	79

PLU: Predominant Length of Utterance (Vainikka et al. 1999)

Utterances = Total number of Utterances

Verbal Utterances = Utterances with verbs

Table 4. Adult-like usage of temporal/aspectual markers by BB, out of total verbal utterances (**Bold** = statistically significant: $p < 0.05$)

	3b	Adult	Two-tailed, Fisher's exact	4b	Adult	Two-tailed, Fisher's exact
S-*le*	(4/81) 4.9%	(54/266) 20.3%	$p <$ **0.001**	(69/414) 16.7%	(49/272) 18.0%	$p < 0.7$
V-*le*	0	(3/266) 1.1%	$p < 1.0$	0	(1/272) 0.4%	$p < 0.4$
Prog. *ne*	(4/81) 4.9%	(4/266) 1.5%	$p < 0.09$	(1/414) 0.2%	(7/272) 2.6%	$p <$ **0.008**

Table 5. Adult-like usage of temporal/aspectual markers by YY, out of total verbal utterances (**Bold** = statistically significant: $p < 0.05$)

	3b	Adult	Two-tailed, Fisher's exact	4b	Adult	Two-tailed, Fisher's exact
S-*le*	(3/161) 1.9%	(76/267) 28.5%	$p <$ **0.0001**	(28/163) 17.2%	(76/319) 23.8%	$p < 0.1$
V-*le*	0	(2/267) 0.7%	$p < 0.6$	(1/163) 0.6%	(3/319) 0.9%	$p < 0.6$
Prog. *ne*	(12/161) 7.5%	(4/267) 1.5%	$p <$ **0.01**	(2/163) 1.2%	(9/319) 2.8%	$p < 0.4$

Table 6. Adult-like usage of temporal/aspectual markers by LXB, out of total verbal utterances (**Bold** = statistically significant: $p < 0.05$)

	3b	Adult	Two-tailed, Fisher's exact	4b	Adult	Two-tailed, Fisher's exact
S-*le*	(8/126) 6.3%	(83/302) 27.5%	$p <$ **0.0001**	(15/79) 19.0%	(58/311) 18.6%	$p < 1.0$
V-*le*	0	(4/302) 1.3%	$p < 0.4$	0	(4/311) 1.3%	$p < 0.6$
Prog. *ne*	(2/126) 1.6%	(3/302) 1.0%	$p < 0.7$	(2/79) 2.5%	(3/311) 1.0%	$p < 0.3$

Table 7. Determining error percentages

Adult S-*le* target: 22.5% (514/2281)	BB 3b	BB 4b	YY 3b	YY 4b	LXB 3b	LXB 4b
1. Verbal utterances made by child	81	414	161	163	126	79
2. Predicted occurrences of S-*le*	18.2	93.2	36.2	36.7	28.4	17.8
3. S-*le* produced	4	69	3	28	8	15
4. % of success in producing S-*le*	21.9 %	74.1 %	8.3%	76.3%	28.2%	84.4%
5. *ne* substitutions produced	2	1	21	8	14	2
6. % of *ne* substitutions	11.0%	1.1%	58.0%	21.8%	49.4%	11.3%
7. Other errors (omissions)	67.1%	24.9%	33.7%	1.8%	22.4%	4.4%

Table 8. Formal analysis vs. empirical observation of tense/aspectual markers (3b–BB)

	Theoretical	**Observed**
le	25%	22%
ne	25%	11%
Ø	50%	67%

Table 9. Formal analysis vs. empirical observation of tense/aspectual markers (3b–LXB)

	Theoretical	**Observed**
le	25%	28%
ne	50%	49%
Ø	25%	22%

Table 10. Theoretical vs. empirical morphology (4b–BB)

	Theoretical	**Observed**
le	75%	74%
ne	0%	1%
Ø	25%	25%

Table 11. Theoretical vs. empirical morphology (4b–YY,LXB)

	Theoretical	**Observed (YY, LXB)**	
le	75%	76%	84%
ne	25%	22%	11%
Ø	0%	2%	4%

Table 12. Child Mandarin production (* = errors)

Interpretation	Form
inchoative aspect	le
*inchoative aspect	*ne (default)
*inchoative aspect	*Ø
progressive aspect	ne

Tableau 1. ***Production*** of the inchoative: [incept], [inchoative] ?

	Expressions		$*F^2$	PARSET	PARSEASP	*F
a	VP	*Ø*		*!	*	
b ☞	$TP_{[incept]}$	*ne*			*	*
c	$AspP_{[inchoative]}$	*Ø*		*!		*
d	$TP_{[incept]}$ + $AspP_{[inchoative]}$	*le*	*!			*

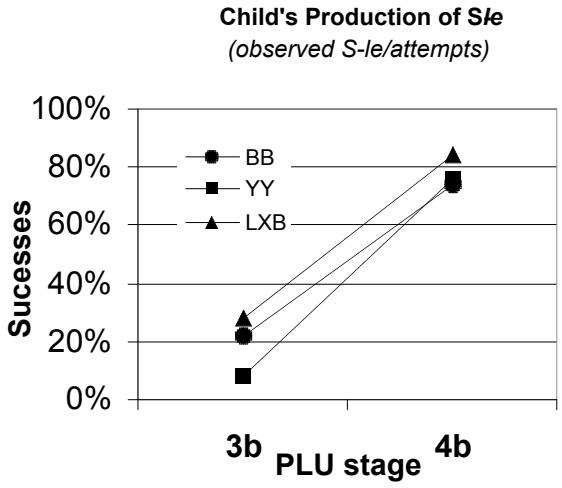
Tableau 2. ***Comprehension*** of *ne*: *ne* = TP □ ?

	Interpretations	*F[2]	PARSET	PARSEASP	*F	FILLT	FILLASP
a	Ø				*	*!	
b ≫	[T]				*		
c	[inchoative]			*!	*	*	
d	[incept], [inchoative]			*!	*		

Tableau 3. ***Comprehension*** of *le*: *le* = $TP_{[incept]}$ + $AspP_{[inchoative]}$ □ ?

	Interpretations	*F^2	PARSET	PARSEASP	*F	FILLT	FILLASP
a	Ø	*			**	*!	*
b	[T]	*			**		*!
c	[inchoative]	*			**	*!	
d ↠	[incept], [inchoative]	*			**		

Figure 1. Development of S-*le* used inchoatively



Figures 2. Development of *ne* used inchoatively

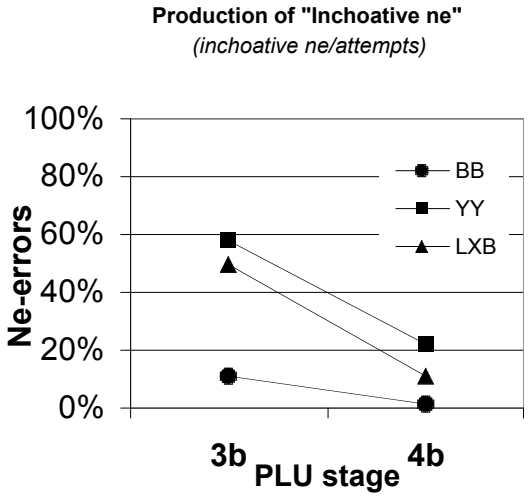


Figure 3. Development of other inchoative errors

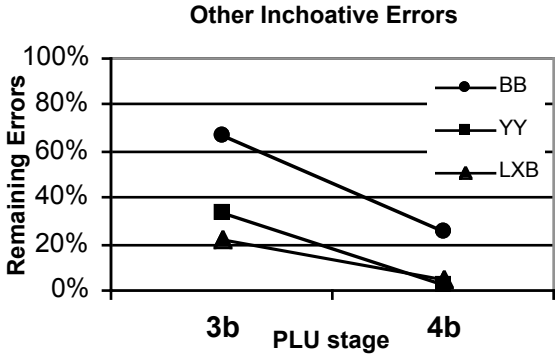


Figure 4. Candidate structures

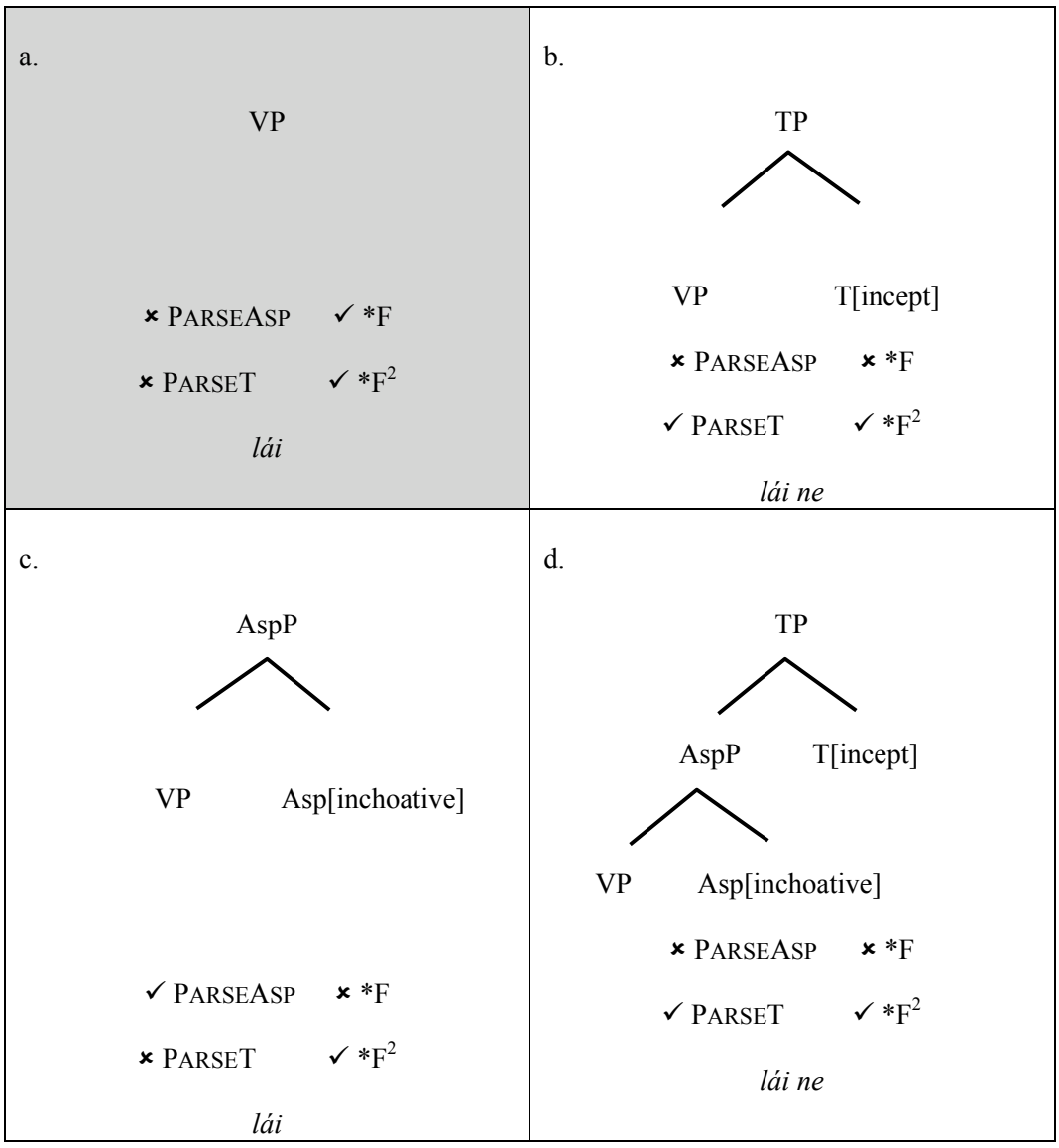
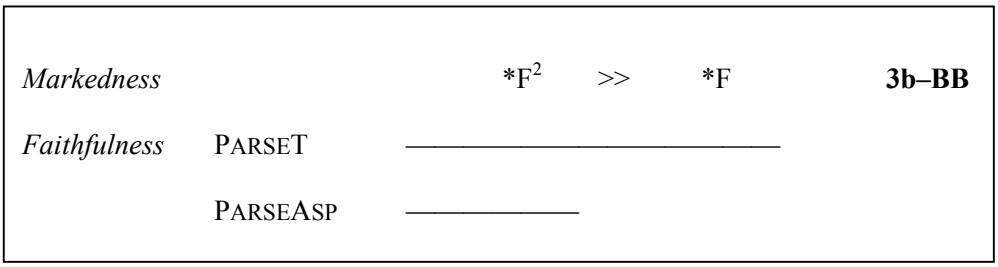


Figure 5. A partial ranking for Stage 3b (BB)



Possible rankings and results:

a. PARSET >> PARSEASP >> *F^2 >> *F ☐ TP+AspP (*le*)

b. PARSEASP >> PARSET >> *F^2 >> *F ☐ TP+AspP (*le*)

c. PARSEASP >> *F^2 >> PARSET >> *F ☐ AspP (*Ø*)

d. PARSEASP >> *F^2 >> *F >> PARSET ☐ AspP (*Ø*)

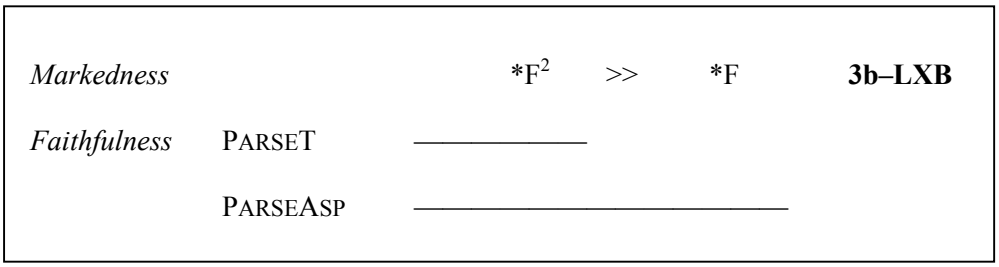
e. PARSET >> *F^2 >> PARSEASP >> *F ☐ TP (*ne*)

f. *F^2 >> PARSET >> PARSEASP >> *F ☐ TP (*ne*)

g. *F^2 >> PARSEASP >> PARSET >> *F ☐ AspP (*Ø*)

h. *F^2 >> PARSEASP >> *F >> PARSET ☐ AspP (*Ø*)

Figure 6. A partial ranking for Stage 3b (LXB)



Possible rankings and their results:

a. PARSEASP >> PARSET >> *F² >> *F TP+AspP (*le*)

b. PARSET >> PARSEASP >> *F² >> *F TP+AspP (*le*)

c. PARSET >> *F² >> PARSEASP >> *F TP (*ne*)

d. PARSET >> *F² >> *F >> PARSEASP TP (*ne*)

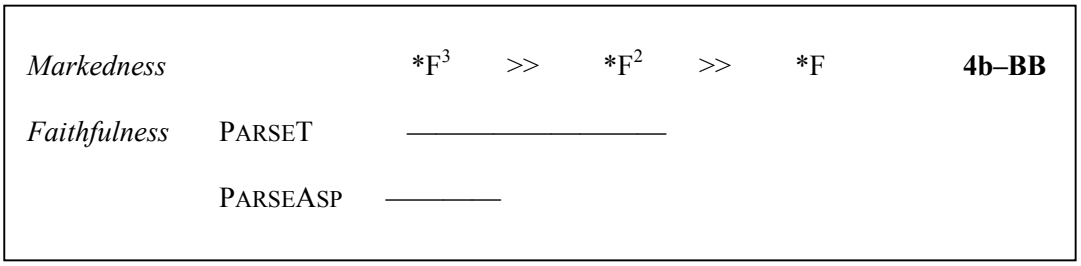
e. PARSEASP >> *F² >> PARSET >> *F AspP (*Ø*)

f. *F² >> PARSEASP >> PARSET >> *F AspP (*Ø*)

g. *F² >> PARSET >> PARSEASP >> *F TP (*ne*)

h. *F² >> PARSET >> *F >> PARSEASP TP (*ne*)

Figure 7. A partial ordering for Stage 4b (BB)



Possible rankings and their results:

a. PARSEASP >> PARSET >> *F^3 >> *F^2 ☐ AspP+TP (*le*)

b. PARSET >> PARSEASP >> *F^3 >> *F^2 ☐ AspP+TP (*le*)

c. PARSET >> *F^3 >> PARSEASP >> *F^2 ☐ AspP+TP (*le*)

d. PARSEASP >> *F^3 >> PARSET >> *F^2 ☐ AspP+TP (*le*)

e. *F^3 >> PARSEASP >> PARSET >> *F^2 ☐ AspP+TP (*le*)

f. *F^3 >> PARSET >> PARSEASP >> *F^2 ☐ AspP+TP (*le*)

g. PARSEASP >> *F^3 >> *F^2 >> PARSET ☐ AspP (*Ø*)

h. *F^3 >> PARSEASP >> *F^2 >> PARSET ☐ AspP (*Ø*)

Figure 8. A partial ranking for Stage 4b (YY, LXB)

Markedness		*F^3	>>	*F^2	>>	*F	**4b–YY, LXB**
Faithfulness	PARSET	————					
	PARSEASP	——————————--					

Possible rankings and their results:

a. PARSET >> PARSEASP >> *F^3 >> *F^2 □ AspP+TP (*le*)

b. PARSEASP >> PARSET >> *F^3 >> *F^2 □ AspP+TP (*le*)

c. PARSEASP >> *F^3 >> PARSET >> *F^2 □ AspP+TP (*le*)

d. PARSET >> *F^3 >> PARSEASP >> *F^2 □ AspP+TP (*le*)

e. *F^3 >> PARSET >> PARSEASP >> *F^2 □ AspP+TP (*le*)

f. *F^3 >> PARSEASP >> PARSET >> *F^2 □ AspP+TP (*le*)

g. PARSET >> *F^3 >> *F^2 >> PARSEASP □ TP (*ne*)

h. *F^3 >> PARSET >> *F^2 >> PARSEASP □ TP (*ne*)

Figure 9. Theoretical vs. observed values for stage 3b

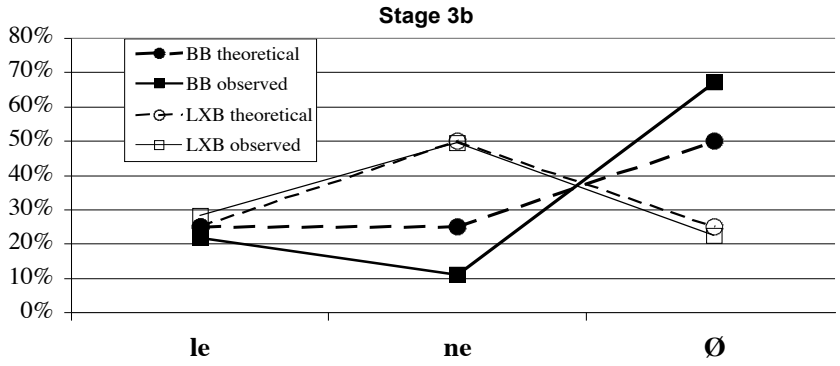
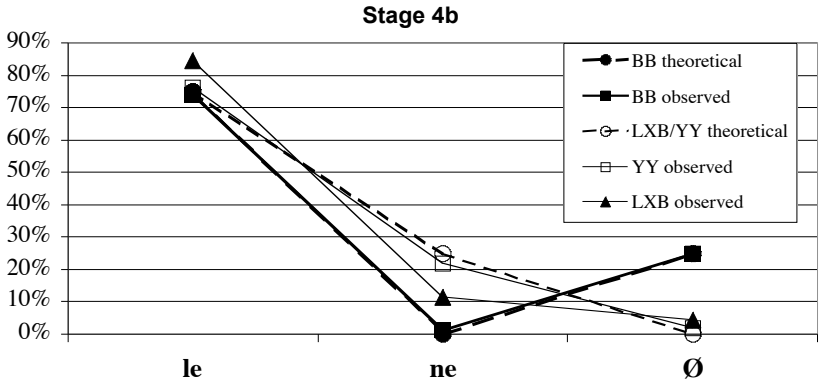


Figure 10. Theoretical vs. observed values for stage 4b.



Notes

* This paper is a revised version of our presentation at the PIONEER-Workshop on Variation in Form versus Variation in Meaning held at the University of Nijmegen in July 2002. We thank the organizers, the audience, and two reviewers for their comments, and Isabelle Barrière for discussion of controversial issues in early acquisition. We are grateful to Zhu Bo for re-coding a sample of the data. This research was supported by a National Science Foundation grant, Learning and Intelligence Systems number NSF–9720412. The usual disclaimers apply.

[1] We cannot do justice here to the intricacies of the meaning contributed by S-*le*; see Chan (1980), Sybesma (2001) for more extensive discussion.

[2] A-to-CH, CH-to-A, etc. stand for Adult-to-Child, Child-to-Adult utterances, respectively. References such as 'BBvis5' are references to data from the CHILDES database; in this case, from the transcript of the fifth visit with child BB. Only five files are available for each child. Two files far apart were analyzed to maximize the chance of obtaining two different stages of development.

[3] Smith (1991) and Li (1990) consider S-*le* and V-*le* to be the same particle, although we take the fact that they can co-occur in a sentence, e.g., in (2b), as an argument against that view.

[4] Of course a full account of the morphological system of Mandarin would have many more morphological rules and probably more complex conditions, but we assume that the marked–unmarked relationship between *le* and *ne* would be preserved in the more completely spelled-out system. In accord with (7), S-*le* and *ne* realize T and so can

co-occur with particles that are overt realizations of Asp (for example, *ne* frequently occurs with *zhe* and *zai*, and *le* can occur with *guo* and also, somewhat less naturally, with *zhe* and *zai*).

[5] The following instance of *la* produced by BB at stage 3b was the single discrepancy between our coding and the coding of our independent rater: [=! crying] *mei2 la::* 'No more!' (lit. neg (exist) *le* + interj. *a*). (BB vis1). Whereas our independent rater believes *la* must be *S-le + a*, we coded it more conservatively as an *S/V-le*, a conflation of *S-le* and *V-le.* Based on the categories discussed in Table 2, either coding resulted in including this instance of *la* as inchoative S-*le.*

[6] Tardif (1993) provides MLUs modified for Mandarin, but averaged over all of her subjects. In the first files we examined, the average MLU is 2.03, and in the last files, the average MLU is 2.78.

[7]To get the adult figures, we coded, for each file, the first 400 utterances of child-directed adult speech from one parent. The files BBvis5 (stage 4b) and YYvis5 (stage 4b) included slightly less than 400 such utterances.

[8] Following common practice, we take a *p*-value less than 0.05 to indicate a significant difference (i.e., the chances would be 5% or less of obtaining a sample difference as large as the one observed if the child's rate of use of a form were in fact the same as the adult's).

[9] "Zhàn" is the correct pronunciation for 'stop.'

[10] The pattern does not appear to be phonological in nature either. We noted that *zhe* and *guo* are almost unattested in the early transcripts, although the children do

produce words starting with [_] and [g^w]. It is the systematicity revealed by the markers that do appear which we attempt to account for here.

[11] Anttila (1994), Boersma (1997), and Reynolds (1994) introduced partial constraint rankings to model variation in adult grammars.

[12] Erbaugh does not distinguish the two *le*s (perfective V-*le* vs. inchoative/current relevance S-*le*) from one another in her counts. She comments that many of the 2,300 tokens she collected could be interpreted correctly either way. She does not report any percentages for *ne* although she mentions its function as a temporal/aspectual marker in passing. According to Cheng (1985) *ne* is more characteristic of Beijing Mandarin than Taiwanese Mandarin (the variant spoken by her young subjects).

[13] While YY's data at 3b and development from 3b to 4b followed the same qualitative trend as BB and LXB (see Tables 5 and 7), quantitatively, the proportions of correct, incorrect, and missing productions of inchoative input could not be satisfyingly matched with possible predicted proportions. This illustrates the limitations of the partial ranking model's power, suggesting a modification is needed; this is a topic of future research (see Davidson and Legendre, (in press) for relevant discussion in the context of Catalan acquisition). However, we may also glean a positive interpretation of this limitation: our model is not so powerful as to be able to account for any data. Any modification should preserve this characteristic.

[14] This is not to say that a change of processing capacity plays no role in the development of the temporal markers. In fact, it may prove possible to construe our

constraints against building up syntactic structure as the formal grammatical encoding of certain working memory limitations.

[15] It would be extremely helpful to have comprehension studies to refer to but they are notoriously difficult to conduct on children younger than 2 years of age. All reported studies of comprehension of tense/aspect in Mandarin have been conducted on much older children (Li & Shirai, 2000). However, recent developments in methodology should allow us to conduct a follow-up study testing the prediction we elaborate on below. Specifically, the Intermodal Preferential Looking Paradigm which measures the child's visual attention to audio stimuli paired up with appropriate vs. inappropriate scenes displayed on two screens has been quite successful at tapping very young children's and even infants' comprehension of language (Golinkoff &, Hirsh-Pasek, Cauley, & Gordon, 1995).

[16] As a simple example of the pivotal role of covert structure consider a child learning a language in which grammatical functions are marked solely by word order. Suppose the adult word order is OVS; suppose also that the child's constraints governing head direction are incorrectly ranked, so as to render optimal the [S[VO]] structure rather than the correct bracketing [[OV]S]. The mis-ranking of these head-alignment constraints would lead the child to erroneously produce SVO sentences. In comprehension, the same error would occur, since the same mis-ranking favors the wrong bracketing and there is (by assumption) no overt material ruling out SVO as a possible analysis.

[17] The structural competition alluded to in the text is actually relevant here. From (7), *ne* is the realization of either a TP with the unspecified tense feature [T] or a TP with

[incept] on the head T. Thus both these structures appear in the competing interpretations. For candidate *d*, the latter is the optimal structure: PARSET is satisfied with T bearing [incept]. In the optimal structure for *a*, T does not bear [incept], for this would violate FILLT.

[18] Unlike the simpler approach taken here, bi-directional optimization is, however, a powerful theory of *blocking*: if a less-marked expression is available in virtue of having the correct interpretation, it blocks a more-marked expression that would otherwise be optimal. In Wilson's original proposal, anaphors enter the candidate set only when they have the correct binder, and when available, anaphors block pronouns because they are more structurally economical.

[19] De Hoop (2000, to appear) provides independent evidence against the super-optimality view of bi-directional optimization, based on adult scrambling in Dutch.