Learning Attitude Verb Meanings in a Morphosyntactically-Poor Language

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1. Introduction

Word meanings are learned under less-than-ideal conditions: in principle, a word can have many possible meanings, and learners must choose the correct one with limited explicit instruction. This problem seems to be exacerbated in the context of attitude verbs, like *think*, *believe*, *want*, which describe abstract mental states. These verbs lack reliable physical correlates in the real world, so the non-linguistic context provides very limited information to the learner about their meanings. An influential proposal addressing this learning problem posits that learners rely on linguistic context to learn their meanings, via syntactic bootstrapping (Gleitman, 1990; Gleitman et al., 2005; Papafragou et al., 2007; Gillette et al., 1999, etc.). In this paper, we investigate the feasibility of syntactic bootstrapping in a morphosyntactically poor language. We are interested in the fact that cross-linguistically, children seem to master at a relatively early age the semantic differences between "belief verbs" like *think*, *believe*, which express judgments of truth, and "desire verbs" like *want*, *love*, that express preferences (e.g. Bolinger, 1968; Hooper, 1975; Villalta, 2008).

In particular, we explore the Declarative Main Clause Syntax Hypothesis (e.g. Hacquard and Lidz, to appear; Hacquard, 2014; Lidz et al., to appear; Harrigan et al., 2016), a syntactic bootstrapping account for attitude verb meanings, taking Mandarin Chinese as a case study. In principle, Mandarin offers relatively few cues for syntactic bootstrapping purposes, as it has minimal verbal and nominal morphology and allows null arguments. If the Declarative Main Clause Syntax Hypothesis is a viable learning strategy in Mandarin, then it is likely to be just as viable in languages that are similarly morphosyntactically impoverished, and even more viable in languages with richer morphosyntax.

This paper is organized as follows: Section 2 presents the Declarative Main Clause Syntax Hypothesis and the syntactic properties of Mandarin belief and desire verbs. Sections 3 and 4 present and discuss the results of two corpus studies. We argue that there are enough morphosyntactic cues in Mandarin

Chinese for learners to learn semantic differences between attitude verbs, in a way consistent with the hypothesis. We discuss open questions and future work in Section 5 and conclude in Section 6.

2. Learning attitude verb meanings via syntactic bootstrapping
2.1. Motivating the Declarative Main Clause Syntax Hypothesis

The literature on the semantics of attitude verbs shows that the belief/desire split has syntactic correlates: belief verbs, which express commitments to the truth of the complement ("representational attitudes," Bolinger, 1968, among others), have complements that are syntactically different from desire verbs, which express preferences. For example, in English, belief verbs tend to take finite complements (1a), while desire verbs tend to take non-finite ones (1b). In German, belief verbs can take complements with verb-second word order (2a), but desire verbs cannot (2b). In Romance, belief verbs take complements in the indicative mood (3a), while desire verbs take subjunctive complements (3b).

(1)   English
        a.   John thinks [Mary will leave].   [Belief verb]
        b.   John wants [Mary to leave].   [Desire verb]
(2)   German (adapted from Scheffler, 2009 exx. 1-2)
        a.   Ich glaube, [Peter ist nach Hause gegangen].   [Belief verb]
               I   believe Peter is   to   home   gone
               'I believe that Peter has gone home.'
        b. * Ich möchte, [Peter geht nach Hause].   [Desire verb]
               I   want   Peter goes to   home
               'I want Peter to go home.'
(3)   Spanish
        a.   Creo   [que Peter va   a   la   casa].   [Belief verb]
               I.think that Peter goes.IND to the house
               'I think Peter is going to the house.'
        b.   Quiero [que   Peter vaya   a   la   casa].   [Desire verb]
               I.want   that   Peter goes.SBJ to   the house
               'I want Peter to go to the house.'

While belief and desire verbs have distinct morphosyntactic properties in English, German, and Romance, the examples above also show that these two classes of attitude verbs are distinct in language-specific ways: in English, the relevant distinction appears to be finiteness; in German, it is whether verb-second word order is possible; in Romance, it is mood. Despite the morphosyntactic diversity, in these languages, clausal complements of belief verbs have one thing in common: they have the same morphosyntactic profile as declarative main clauses (Hacquard and Lidz, to appear; Hacquard, 2014): English main clauses are finite, German main clauses have verb-second word order, and Romance main clauses are in the indicative mood.

From a learning perspective, a learner who is sensitive to these syntactic properties in clausal complements and can track them fairly accurately will be able to infer that there are two types of attitude verbs. However, this sensitivity alone does not guarantee that learners will draw the correct (adult-like) inferences about the semantics of each verb class; such a learner might end up assigning desire semantics to *think* and belief semantics to *want*. The Declarative Main Clause Syntax Hypothesis provides a solution: learners exploit speech act similarities between belief verbs and declarative main clauses to make the right semantic inferences.

More specifically, consider the fact that a declarative clause like *Mary is late* is typically used to make assertions. The attitude verbs literature has often observed that belief verbs are "assertive" (e.g. Hooper 1975, see also Dayal and Grimshaw, 2009) in that they can be used to indirectly assert their complement. The reason belief verbs are naturally assertive is that they express a commitment to the truth of the complement, a commitment that the speaker can implicitly endorse, and in so doing indirectly assert the complement. These verbs tend to take a clausal complement that resembles a declarative main clause, e.g. *They think Mary is late*. Presented with such a sentence, a learner might infer that the speaker also intends to assert the clausal complement, albeit indirectly.[1] If so, he/she might infer that the verb *think* has a meaning that is compatible with indirect assertions, i.e. *think* expresses a judgment of truth (belief). In contrast, the learner does not assign belief semantics to a verb whose clausal complement does not resemble a declarative main clause, since these verbs are not assertive. We assume that he/she assigns desire semantics to these verbs.

As a model of language acquisition, then, the Declarative Main Clause Syntax Hypothesis can be re-cast as the following set of hypotheses: (1) There are principled differences in the morphosyntactic properties of the clausal complements of belief and desire predicates. (2) These morphosyntactic differences are present in speech to children. (3) Children can detect these differences. (4) They use these differences to assign belief and desire semantics, as described above. Our goal in this paper is to provide evidence for the first two hypotheses in the context of a morphosyntactically-poor language, to lay the groundwork for testing the third and fourth hypotheses.

2.2. Syntactic properties of clausal complements in Mandarin Chinese

Seen in this light, Mandarin Chinese clausal complements seem to present challenges for a syntactic bootstrapping account. Mandarin allows null arguments and lacks case, tense, mood morphology, which raises questions as to whether it makes a finiteness contrast and whether its attitude verbs differ in

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[1] This requires a learner who can determine the force of an utterance: whether the utterance carries declarative force or interrogative force, etc. A body of research suggests that this is possible: children are good at identifying the force of speech acts (Grosse et al., 2010; Grosse and Tomasello, 2012; Begus and Southgate, 2012, among others).

their subcategorization/selection requirements (e.g. C.-T. J. Huang, 1989; Li, 1990; Hu et al., 2001; Lin, 2012; Grano, 2015, N. Huang, under review). Further, unlike e.g. German, Mandarin does not use word order to distinguish its clausal complements.

We argue here that there are syntactic properties in Mandarin that generally distinguish the clausal complements of belief verbs from those of desire verbs. The literature on Mandarin syntax (e.g. C.-T. J. Huang, 1989) shows that complements of desire verbs generally require null subjects, while those of belief verbs can have subjects that are either overt or null (4). In addition, unlike desire verbs' complements, belief verbs' complements allow modal auxiliaries (5), and certain aspect markers, e.g. progressive *zai*, experiential *guo*, negative perfective *mei(you)* (6). Importantly, these properties also broadly distinguish declarative main clauses from other clause types, e.g. imperatives, which do not allow most modal auxiliaries (e.g. *hui* "will") or aspect markers.

Although the presence/absence of three properties are associated cross-linguistically with finiteness, in this paper, we will not address the theoretical debate over whether Mandarin makes a finiteness distinction. Nor is it necessary to hypothesize that Mandarin learners use finiteness for syntactic bootstrapping purposes. Rather, for the purpose of this discussion, we will assume that learners have enough syntactic knowledge to recognize subjects, modals, and aspect morphemes, and can track their distribution in clauses.

(4)   Overt subjects
    a. Lisi renwei [(<u>Zhangsan</u>) chi-su].   [Belief verb]
        Lisi think   Zhangsan   eat-vegetarian
        'Lisi thinks that Zhangsan is vegetarian.'
    b. Lisi {*xiang / yao} [(<u>Zhangsan</u>) chi-su].   [Desire verb]
        Lisi   want   want   Zhangsan   eat-vegetarian
        Intended: 'Lisi wants Zhangsan to be vegetarian.'
    c. Lisi xiang [chi-su].   [Desire verb]
        Lisi want   eat-vegetarian
        'Lisi wants to be vegetarian.'
(5)   Modal auxiliaries and adverbs
    a. Lisi renwei [Zhangsan {<u>keneng</u> / <u>hui</u>} qu paobu].   [Belief verb]
        Lisi think   Zhangsan perhaps will go   run
        'Lisi thinks Zhangsan {might / will} go running.'
    b. Lisi {xiang / yao}   [{*<u>keneng</u> / *<u>hui</u>} qu paobu].   [Desire verb]
        Lisi want   want   perhaps   will go   run
        Intended: 'In all of Lisi's desire worlds, it {is perhaps / will be} the case that he goes running.'
(6)   Aspect markers
    a. Lisi renwei [Zhangsan <u>zai</u>   shuijiao].   [Belief verb]
        Lisi think   Zhangsan PROG   sleep
        'Lisi thinks Zhangsan is sleeping.'

b. Lisi {xiang / yao} [(*<u>zai</u>)   shuijiao].   [Desire verb]
Lisi want   want   PROG sleep
Intended: 'Lisi wants to be sleeping.'

As (4b) shows, there are exceptions to these generalizations: even though *yao* "want" is a desire verb, like its English counterpart, its complement can contain an overt subject. However, looking at a much larger set of attitude predicates (Table 1), we find that the generalizations about overt subjects, modals, and aspect markers are fairly robust. Nonetheless, these exceptions complicate the language acquisition process, as they are a source of noise.

Table 1: A selection of Mandarin Chinese attitude verbs

Verb class/Clause type	Overt subject	Modal	Aspect
Belief verbs	Possible	Possible	Possible
danxin "worry"; *faxian* "discover"; *huaiyi* "doubt"; *jiang* "tell"; *juede* "feel"; *mingbai* "understand"; *renwei* "think"; *shuo* "say"; *xiang* "think"; *xiangxin* "believe"; *yiwei* "falsely believe"; *zhidao* "know"			
Desire verbs			
taoyan "dislike"; *xihuan* "like"; *yao* "want / need"	Possible	Not possible	Not possible
ai "love"; *gan* "dare"; *xiang* "want"; *yao* (future marker)	Not possible	Not possible	Not possible
dasuan "plan"; *zhunbei* "get ready to"	Disputed (see Zhang, 2016; Grano, 2015; Hu et al., 2001)	Only *yao* (future marker)	Not possible
Emotive doxastic verbs			
xiwang "hope"	Possible	Possible	Possible
Declarative main clause	Possible	Possible	Possible

A more serious problem for the Declarative Main Clause Syntax Hypothesis is the fact that these three properties are all optional: given the right context and predicate, the complement of a belief verb can have a subject that is phonologically null, and appear without a modal or aspect marker. In other words, this complement is string-identical to that of a desire verb (7). If attitude verbs generally occur in these environments in the input, there would be little or no observable difference between the complements of belief verbs and those of desire verbs. If so, syntactic bootstrapping would not be viable as a strategy for learning the semantic differences between attitude verbs.

(7)   a.   Wo zhidao [chi shuiguo].   [Belief verb]
             I   know   eat fruit

'I know [{I/you/he/she/it/...}] eat(s) fruit.'
    b.   Wo ai   [chi shuiguo].   [Desire verb]
        I   love   eat fruit
        'I love to eat fruit.'

A second potential problem is related to the fact that declarative main clauses can also appear with a null subject and without modals or aspect markers (8). If they do so most of the time, then according to the learning scenario sketched above, learners might conclude that desire verbs have complements that resemble declarative main clauses, and are used to make indirect assertions. This learner would then mistakenly assign belief semantics to desire verbs.

(8)   [Chi   shuiguo].
         eat   fruit
         '{I/you/he/she/it/...} eat(s) fruit.'

3. Corpus studies

We show that the above problems are only apparent with a corpus study of Mandarin child-ambient speech. To preview our results, we find that even though overt subjects, modals, and aspect markers are in principle optional in the complement clauses of belief verbs, these properties occur relatively frequently, so that complements of belief verbs do not resemble those of desire verb complements. Second, these syntactic properties occur in complements of belief verbs about as frequently as in declarative main clauses.

3.1. Mandarin Chinese CHILDES corpus study
3.1.1. Methods

We selected four Mandarin Chinese corpora from the CHILDES database (MacWhinney, 2000): Beijing (Tardif, 1993, 1996), Context (Tardif et al., 1999), Chang (Chang, 1998), Zhou1 (collected by Jing Zhou). The target children were around 1;9.3 to 6 years of age. As each corpus is relatively small, we pooled all four corpora for analysis, even though the data were collected under relatively different conditions.

We extracted two sets of data from our corpora to compare the distribution of syntactic features like overt vs. null subjects, modals, and aspect markers in complements of attitude verbs and those of main clauses. The first contains all utterances with the attitude verbs in Table 1, about 6,000 tokens in total. For each token, the complement of the attitude verb was manually coded for syntactic category: whether it had the form of a clause, a VP, an NP, and so on. For our analysis, we only looked at the approximately 2,500 "clause-like" complements – complements with the form of a clause or a VP (Table 2). NP

and other kinds of complements were excluded from analysis. The complement was further coded for the presence of an overt subject, modal, or aspect marker.[2]

Table 2: Verbs with clause-like complements in the CHILDES dataset

	Count		Count
Belief verbs		Desire verbs	
shuo "say"	643	*yao* "want/need"	1,084
zhidao "know"	180	*xiang* "think, want"	260
jiang "tell"	76	*ai* "love"	163
yiwei "mistakenly believe"	17	*xihuan* "like"	52
juede "feel"	9	*gan* "dare"	26
faxian "discover"	1	*zhunbei* "get ready to"	8
renwei "think"	1	Total	2,520

The second set of data is what we will call the main clause dataset, a 5% random sample of child-ambient utterances from each file of each corpus (6,100 tokens in total). In this dataset, each utterance was coded for its clause type: whether it was a declarative, interrogative, imperative, and so on. When it was difficult to determine clause type from the utterance itself, the context was checked. The main clause of each utterance was coded for the presence of an overt subject, modal, or aspect marker. For our analysis, we looked at 1,131 declarative main clauses, after excluding utterances of other clause types, formulaic phrases, disfluencies, repetitions of utterances by the child etc.

We note here that we excluded from analysis all instances of the perfective aspect *le*, as it was often difficult to determine from the context whether *le* was intended as the perfective aspect or as the homophonous change-of-state sentence-final particle, which is not an aspect marker. As a result, our aspect marker frequencies should be understood as a conservative estimate.

Annotations were done manually by the first author and an undergraduate research assistant, who are native speakers of Mandarin Chinese. A smaller sample of utterances (1,310 utterances from the attitude verb dataset, 700 utterances from the main clause dataset) was independently annotated by the second author, who is also a native speaker. Excluding irrelevant utterances (e.g. disfluencies, formulaic phrases, nondeclarative clauses), inter-annotator

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[2] For the corpus analysis, the following items and their negated forms were defined as modal auxiliaries and adverbs (i) and aspect markers (ii).
(i) a. Epistemics: *keneng* "might", *yiding* "must"
     b. Roots: *bixu*, *dei*, *yao*, *yiding* "must"; *ken* "be willing to"; *ke(yi)* "can, be allowed to"; *hui*, *neng(gou)* "able to"; *(ying)gai*, *ying* "should"
     c. Future: *hui*, *jiang*
     d. Others: *bie* prohibitive (negative imperative)
(ii) a. Aspect suffixes: *-guo* experiential; *-le* perfective (Chinese Treebank analysis only); *-zhe* durative
     b. Progressive: *(zheng)zai*
     c. Negation: *mei(you)* negated perfective

agreement was 99% for the first dataset (Cohen's kappa = 0.8, p < 0.0001), and 94% for the second dataset (Cohen's kappa = 0.7, p < 0.0001).

3.1.2. Results

Table 3 presents average frequencies of overt subjects, modals, and aspect markers in the main clause dataset and in the attitude verb dataset, at the verb class level. Belief verbs have complements that resemble declarative main clauses in terms of the distribution of overt subjects, modals, and aspect markers; in contrast, desire verbs do not. Because *xiang* is polysemous with belief and desire readings, we report its figures separately.

Figure 1 shows 95% confidence intervals for these properties at the verb class level. Confidence intervals were calculated by statistical bootstrapping. For each verb class and the set of main clauses, a set of utterances of the same size as the original was created by sampling with replacement. This process was repeated 5,000 times; confidence intervals were calculated with these samples.

Table 3: Frequencies (%) for overt subjects, modals, and aspect markers in clause-like complements in CHILDES dataset, by verb class

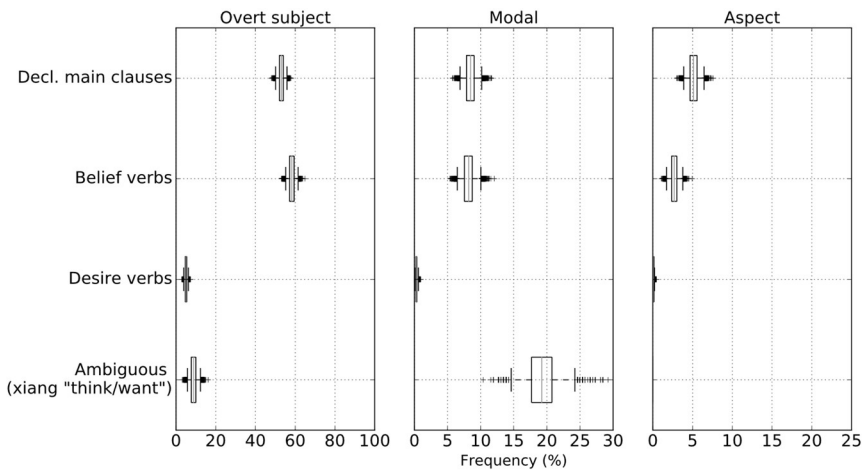| Verb class/Clause type	Overt subject	Modal	Aspect
Declarative main clauses	53	8.5	5.1
Belief verb complements	58	8.2	2.7
Desire verb complements	5.0	0.3	0.1
Complement of *xiang* "think/want"	8.8	19	0

Figure 1: 95% confidence intervals for overt subjects, modals, and aspect markers in CHILDES dataset, by verb class

At the verb level, belief verbs' complements still resemble declarative main clauses, while desire verbs' complements do not. Table 4 presents average frequencies by verb, for the most common belief and desire verbs, while confidence intervals are displayed in Figure 2.

The results for *yao* "want" deserve some comment. As noted in Section 2.2, although it is a desire verb, in principle, *yao* can take a complement with an overt subject. However, in the input, *yao* takes such a complement relatively infrequently, at about 6% of the time. As a result, in the input, the average clause-like complement of *yao* does not resemble the average clause-like complement of belief verbs like *shuo* "say" or *zhidao* "know." In this respect, *yao* patterns more like a prototypical desire verb.

Table 4: Frequencies (%) for overt subjects, modals, and aspect markers in CHILDES dataset, in clause-like complements of most common belief and desire verbs

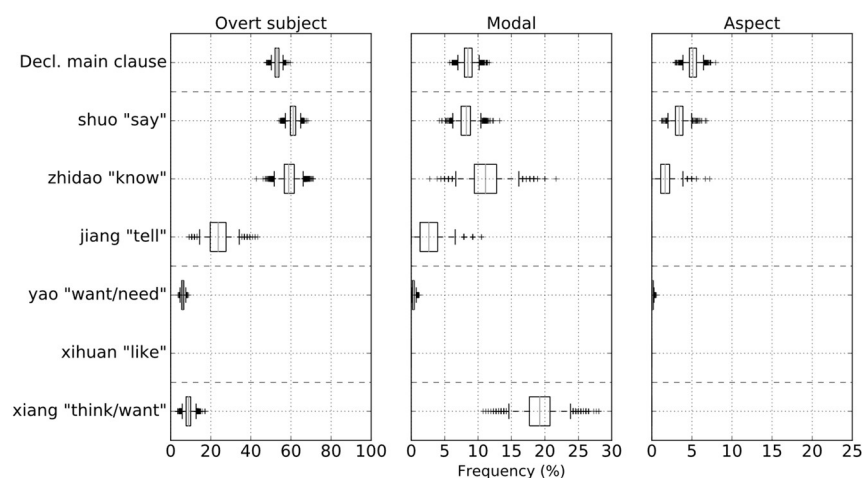| Verb class/Clause type	Overt subject	Modal	Aspect
Declarative main clauses	53	8.5	5.1
Belief verb complements			
- *shuo* "say"	61	8.2	3.4
- *zhidao* "know"	59	11	1.7
- *jiang* "tell"	23	2.6	0
Desire verb complements			
- *yao* "want/need"	6.1	0.4	0.1
- *xihuan* "like"	0	0	0
Complement of *xiang* "think/want"	8.8	19	0

Figure 2: 95% confidence intervals for overt subjects, modals, and aspect markers in CHILDES dataset, for most common verbs

3.2. Chinese Treebank study

One might be concerned about the conclusions that can be drawn from the CHILDES corpus results reported above. Even though we pooled four corpora, the resulting dataset is still relatively small. This raises questions about whether the data is representative of the input encountered by a Mandarin learner.

To address this issue, we did a second corpus study on the Chinese Treebank (Xue et al., 2010). This dataset consists of material that reflects a more formal and/or written register of Mandarin, e.g. newswires, broadcasts, blogs. Although the Chinese Treebank is very different from the CHILDES dataset, it has two useful properties that complement the CHILDES corpus study. First, it is in a machine-readable format, which facilitates analysis on a larger scale. Second, the Chinese Treebank was annotated and checked according to an independent set of standards. Obtaining similar results with the Chinese Treebank would thus validate our CHILDES methods and findings.

3.2.1. Methods

In the Chinese Treebank, as the name suggests, every sentence is assigned a machine-readable tree representation. We wrote a Python script to read each tree to determine the presence of the attitude verbs in Table 1 and to identify the complement(s) they took. We defined clause-like complements as a sister of a verb with the labels CP, IP, or VP. In this analysis, we also included the desire verbs *xuyao* "need" and *yaoqiu* "request," which were not included in the set of verbs in Table 1 because they are of a more formal register. However, they occur quite frequently in the Chinese Treebank and have similar semantics to *yao* "want/need." The same was done for the belief verb *biaoshi* "say, express," which occurs frequently and has *say*-like semantics.

In the event a verb takes conjoined clause-like complements (i.e. where clauses or VP-like constituents are conjoined), the script counted each clause-like conjunct as a separate constituent, yielding 15,879 clause-like complements. The script also extracted its subject, modals, and aspect morphemes, where available. We note that a number of desire verbs are object control verbs, which the Treebank annotated as taking a nominal complement and a clause-like complement with a null subject coreferential with the nominal. For this reason, we classified the clause-like complement of these verbs as having an overt subject if there was an overt nominal complement. Because the Treebank's annotation standards do not define a class of modals, the script checked the complement to see if it contained a lexical item that matched the set of modals listed in Footnote 2. We adopted the Treebank's definition of aspect suffixes and supplemented it with two prefixes with aspect semantics, namely, progressive *zai* and negative *mei*(*you*).

The script also went through each sentence whose root node bore the labels CP or IP and extracted the subject, modal, and aspect morphemes (where available) in the main clause. Likewise, to the extent that a sentence consists of

conjoined clauses, the script counted each clausal conjunct as a separate main clause. Sentences bearing imperative and interrogative force (whose root nodes are marked with -IMP and -Q respectively) were excluded from analysis; we assume that all unmarked sentences bear declarative force. This analysis yielded 67,447 declarative main clauses.

3.2.2. Results

Table 5 presents average frequencies of overt subjects, modals, and aspect markers, by verb class, for the Chinese Treebank dataset; we report separately *xiwang* "hope" and *xiang* "think/want" frequencies because of their semantics. Treebank frequencies differ in magnitude from CHILDES ones, which can be attributed to differences in registers and annotation standards. However, abstracting away from magnitude differences, belief verbs in the Treebank take clause-like complements resembling declarative main clauses in the distribution of overt subjects, modals, and aspect markers. In contrast, desire verbs do not.

Table 5: Frequencies for overt subjects, modals, and aspect markers in clause-like complements in Chinese Treebank dataset, by verb class

Verb class/Clause type	Overt subject	Modal	Aspect
Declarative main clauses	79	8.4	12
Belief verb complements	72	18	9.7
Desire verb complements	11	0.9	0.5
Complements of *xiwang* "hope" and *xiang* "think/want"	39	23	2.1

Likewise, Table 6 shows that at the verb level, clause-like complements of belief verbs resemble main clauses, but those of desire verbs do not. We note that for the second most common desire verb *yaoqiu* "request," overt subjects appear very frequently in its complement. However, the overall syntactic profile of *yaoqiu*'s complement still does not resemble that of declarative main clauses: modals and aspect markers appear much less frequently.

Table 6: Frequencies for overt subjects, modals, and aspect markers in clause-like complements in Chinese Treebank dataset, for most common belief and desire verbs

Verb/Clause type	Overt subject	Modal	Aspect
Declarative main clauses	79	8.4	12
Belief verb complements			
- *shuo* "say"	71	15	11
- *biaoshi* "say"	69	23	8.2
- *renwei* "think"	80	25	6.4
- *zhidao* "know"	72	15	15
- *juede* "feel"	61	16	5.5

Desire verb complements			
- *yao* "want/need"	4	0.7	0.5
- *yaoqiu* "request"	74	3.7	0.3
- *xuyao* "need"	15	0	0.3
Complements of other verbs			
- *xiang* "think/want"	29	13	3.1
- *xiwang* "hope"	50	34	1.1

4. General discussion

There are several takeaways from the corpus studies described above. First, in the CHILDES dataset, aggregating across tokens, belief verbs take complements that clearly resemble declarative main clauses, while desire verbs do not. This contrast holds at the verb class level and at the individual verb level. We can also discount the possibility that the contrast observed in the CHILDES dataset is not representative, as we replicated the same kind of contrast in the much larger, independently-annotated Chinese Treebank dataset.

Second, the clear contrast makes syntactic bootstrapping, e.g. the Declarative Main Clause Syntax Hypothesis, a feasible strategy for learning attitude verb semantics. In Section 2, we argued that even in a morphosyntactically-poor language like Mandarin, the complements of belief and desire verbs are different in principle. However, this alone is not sufficient: for syntactic bootstrapping to work, the differences must be observable in the input. Since the relevant properties are all optional in Mandarin, there could have been few or even no observable differences. In addition, the Declarative Main Clause Syntax Hypothesis requires complements of belief verbs to show syntactic hallmarks of declarative main clauses and desire verbs to not do so. Our results in Section 3 show that these requirements are satisfied in child-ambient speech and more formal registers.

Assuming that children are sensitive to the distribution of these properties in aggregation, we suggest that children learning Mandarin can map syntactic cues to universal meaning differences within the class of attitude verbs, just like their counterparts learning morphosyntactically-richer languages like English, Spanish, or German. Our results constitute a novel argument for syntactic bootstrapping as a universally-applicable strategy for learning semantics, even in languages like Mandarin (e.g. Lee and Naigles, 2005, 2008).

Our results also have implications beyond Mandarin: to the extent that the input in typologically-similar languages – little verbal or nominal morphology, null arguments – show similar contrasts in their clausal complements and declarative main clauses, learners of these languages can also use syntactic bootstrapping to learn the semantics of their attitude verbs.

However, as pointed out above, there are additional hypotheses about the Declarative Main Clause Syntax Hypothesis that the present study does not address. In ongoing work, we plan to assess the hypothesis that children are actually sensitive to these morphosyntactic properties. We do so by studying

how a virtual learner might learn Mandarin attitude verb semantics, building on a computational model for the acquisition of English attitude verbs (White et al., to appear). Likewise, it remains to be seen if learners of Mandarin or other morphosyntactically-poor languages use syntactic cues to work out the meaning of novel attitude verbs, as English learners do, as shown experimentally by Harrigan et al. (2016); Harrigan (2015); Lidz et al. (to appear).

6. Conclusion

In this paper, we examined the Declarative Main Clause Syntax Hypothesis, proposed to explain how children learn attitude verb meanings. Morphosyntactically-poor languages like Mandarin Chinese potentially pose a learning problem and a challenge for the Declarative Main Clause Syntax Hypothesis, since the relevant syntactic properties might be more difficult to observe. We show that this problem is only apparent. Even in a language like Mandarin, there are nonetheless reliable cues to attitude verb meanings in the distribution of morphosyntactic properties. Clausal complements of Mandarin belief and desire verbs have distinct syntactic profiles, not only in principle, but also in aggregation in child-ambient speech. Our corpus results also show that the complements of belief verbs syntactically resemble declarative main clauses, but those of desire verbs do not. The differences in these clauses allow learners who are sensitive to their overall syntactic profile to apply syntactic bootstrapping to learn the differences in verb meanings.

References

Begus, Katarina, and Victoria Southgate. 2012. Infant pointing serves an interrogative function. *Developmental Science* 15:611–617.
Bolinger, Dwight. 1968. *Aspects of language*. New York: Harcourt, Brace, and World.
Chang, Chien-ju. 1998. The development of autonomy in preschool Mandarin Chinese-speaking children's play narratives. *Narrative Inquiry* 8:77–111.
Dayal, Veneeta, and Jane Grimshaw. 2009. Subordination at the interface: the quasi-subordination hypothesis. Manuscript, Rutgers University.
Gillette, Jane, Henry Gleitman, Lila Gleitman, and Anne Lederer. 1999. Human simulations of vocabulary learning. *Cognition* 73:135–176.
Gleitman, Lila. 1990. The structural sources of verb meanings. *Language Acquisition* 1:3–55.
Gleitman, Lila, Kimberly Cassidy, Rebecca Nappa, Anna Papafragou, and John C Trueswell. 2005. Hard words. *Language Learning and Development* 1:23–64.
Grano, Thomas A. 2015. *Control and restructuring*. Oxford University Press.
Grosse, Gerlind, Henrike Moll, and Michael Tomasello. 2010. 21-month-olds understand the cooperative logic of requests. *Journal of Pragmatics* 42:3377–3383.
Grosse, Gerlind, and Michael Tomasello. 2012. Two-year-old children differentiate test questions from genuine questions. *Journal of Child Language* 39:192–204.
Hacquard, Valentine. 2014. Bootstrapping attitudes. In *Proceedings of SALT 24*, 330–352.

Hacquard, Valentine, and Jeffrey Lidz. to appear. Children's attitude problems: Bootstrapping verb meaning from syntax and pragmatics. *Mind and Language*.

Harrigan, Kaitlyn. 2015. Syntactic bootstrapping in the acquisition of attitude verbs. Doctoral Dissertation, University of Maryland.

Harrigan, Kaitlyn, Valentine Hacquard, and Jeffrey Lidz. 2016. Syntactic bootstrapping in the acquisition of attitude verbs: *think*, *want* and *hope*. In *Proceedings of WCCFL 33*, ed. Kyeong-min Kim et al. Cascadilla Proceedings Project.

Hooper, Joan B. 1975. On assertive predicates. In *Syntax and semantics 4*, ed. John Kimball, 91–124. New York: Academy Press.

Hu, Jianhua, Haihua Pan, and Liejiong Xu. 2001. Is there a finite vs. nonfinite distinction in Chinese? *Linguistics* 39:1117–1148.

Huang, C.-T. James. 1989. Pro-drop in Chinese: A generalized control theory. In *The null subject parameter*, ed. Osvaldo A. Jaeggli and Kenneth J. Safir, 185–214. Springer.

Huang, Nick. Under review. Control complements in Mandarin Chinese: implications for restructuring and the Chinese finiteness debate.

Lee, Joanne N, and Letitia R Naigles. 2005. The input to verb learning in Mandarin Chinese: a role for syntactic bootstrapping. *Developmental Psychology* 41:529–540.

Lee, Joanne N, and Letitia R Naigles. 2008. Mandarin learners use syntactic bootstrapping in verb acquisition. *Cognition* 106:1028–1037.

Li, Audrey Y.-H. 1990. *Order and constituency in Mandarin Chinese*. Dordrecht: Kluwer.

Li, Charles N, and Sandra A. Thompson. 1981. *Mandarin Chinese: A functional reference grammar*. Berkeley and Los Angeles: University of California Press.

Lidz, Jeffrey, Rachel Dudley, and Valentine Hacquard. To appear. Children use syntax of complements to determine meanings of novel attitude verbs. In *Proceedings of BUCLD 41*.

Lin, T.-H. Jonah. 2012. Multiple-modal constructions in Mandarin Chinese and their finite properties. *Journal of Linguistics* 48:151–186.

MacWhinney, Brian. 2000. *The CHILDES project: Tools for analyzing talk. Third Edition*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Papafragou, Anna, Kimberly Cassidy, and Lila Gleitman. 2007. When we think about thinking: The acquisition of belief verbs. *Cognition* 105:125–165.

Ren, Fei. 2008. Futurity in Mandarin Chinese. Doctoral Dissertation, The University of Texas at Austin.

Scheffler, Tatjana. 2009. Evidentiality and German attitude verbs. *University of Pennsylvania Working Papers in Linguistics* 15:183–192.

Tardif, Twila. 1993. Adult-to-child speech and language acquisition in Mandarin Chinese. Doctoral Dissertation, Yale University.

Tardif, Twila. 1996. Nouns are not always learned before verbs: Evidence from Mandarin speakers' early vocabularies. *Developmental Psychology* 32:492–504.

Tardif, Twila, Susan A Gelman, and Fan Xu. 1999. Putting the "noun bias" in context: A comparison of English and Mandarin. *Child Development* 70:620–635.

Villalta, Elisabeth. 2008. Mood and gradability: an investigation of the subjunctive mood in Spanish. *Linguistics and Philosophy* 31:467–522.

White, Aaron Steven, Valentine Hacquard, and Jeffrey Lidz. to appear. The labeling problem in syntactic bootstrapping. In *Semantics in acquisition*, ed. Kristen Syrett and Sudha Arunachalam. Amsterdam: John Benjamins.

Xue, Nianwen, Zixin Jiang, Xiuhong Zhong, Martha Palmer, Fei Xia, Fu-Dong Chiou, and Meiyu Chang. 2010. Chinese Treebank 7.0 LDC2010T07.

Zhang, Niina Ning. 2016. Identifying Chinese dependent clauses in the forms of subjects. *Journal of East Asian Linguistics* 25:275–311.