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Mandarin-learning 19-month-old toddlers' sensitivity to word order cues that differentiate unaccusative and unergative verbs

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Abstract

Languages employ different means to manifest the unaccusative-unergative distinction. In Mandarin Chinese, unaccusative verbs are allowed in the inversion construction "V-*le* NP", while unergative verbs are not. This grammaticality contrast brings a presence/absence contrast between the two verb classes in the inversion construction in the input. Using an eye fixation task, we investigated whether Mandarin-learning 19-month-olds were sensitive to this specific input frequency contrast. We found that infants distinguished the grammatical versus ungrammatical uses of the two verb classes in the inversion construction "V-*le* NP" (Experiment 1). When the verb classes were in the "NP V-*le*" order (Experiment 2) (i.e., the same level of grammaticality), infants showed no evidence of a looking difference. These responses indicate toddlers' sensitivity to the distribution of the two verb classes in the inversion construction. This distributional information is likely to be one of the potential cues that facilitate their acquisition of the unaccusative-unergative distinction.

Keywords: early language acquisition; unaccusativity; word order; input frequency; Mandarin Chinese

Introduction

Verbs are a crucial part of language, which we use prototypically to denote events happening around us. Verb learning can be hard: to learn a verb, children not only need to associate accurate meanings with it, but also need to know in what construction(s) it can be used. Transitive verbs, for example, should be used in the transitive frame containing two NPs, while ditransitive verbs are used in the double object construction and/or the PP dative construction. Intransitive verbs seem simpler at first glance, as they only select one NP. However, the intransitive verb class is not homogeneous. Intransitive verbs are divided into unaccusative and unergative verbs. The discussion of how these two verb classes differ syntactically and semantically and in what constructions they can occur has constituted a major topic in theoretical linguistics (e.g., Burzio, 1986; Hoekstra, 1984;

Levin, & Rappaport Hovav, 1995; Perlmutter, 1978; Rosen, 1984; van Valin, 1990; Zaenen, 1988). Despite some theoretical controversies, it is generally acknowledged that the unaccusative-unergative distinction reveals argument structure differences: unaccusative verbs take an internal object argument in the underlying structure and unergative verbs take an external subject argument (shown in (1)).

(1) a. Unaccusative: [$_{IP}$ Leaves$_i$ [$_{VP}$ fell t_i]].
     b. Unergative: [$_{IP}$ Babies [$_{VP}$ cried]].

The unaccusative-unergative distinction is also intriguing for acquisition researchers in that children face potential difficulties in acquiring it. To begin with, the two verb classes are often used in the common intransitive frame "NP V". Lack of a difference on the surface might lead to confusion during acquisition. There are constructions where the distinction is explicit, but different languages employ different means (morphological markings, word order, etc.) to manifest the distinction. Children would have to learn the specific manifestations in their native language. Despite the potential difficulties, a substantial body of studies have revealed children's ability to distinguish unaccusatives from unergatives in their mother tongue before school age (Italian: Lorusso, Caprin, & Guasti, 2005; Vernice, & Guasti, 2014; Dutch: Randall, van Hout, Weissenborn, & Baayen, 2004; English: Becker, & Schaeffer, 2013; Pierce, 1992; French: Snyder, Hyams, & Crisma, 1995; Hebrew, European Portuguese, Palestinian Arabic, and Spanish: Friedmann, & Costa, 2011; Japanese: Sano, Endo, & Yamakoshi, 2001; Mandarin Chinese: Lu, 2019; see also Babyonyshev, Ganger, Pesetsky, & Wexler, 2001 for children's non-adultlike performance).

How do children learning different languages tell the two verb classes apart? Considering the cross-linguistic variance in encoding the unaccusative-unergative distinction, linguistic input should play a role in guiding learning. In this paper, we will take a particular look at the word order cue in a language with no overt morphological markers. In Mandarin Chinese, only unaccusative verbs can occur in the inversion construction, but not unergative verbs. That is to say, normally, inversion constructions with unaccusative verbs are grammatical whereas those with unergative verbs are not. Given the grammaticality contrast, inversion constructions containing unaccusative verbs abound in the input, but those containing unergative verbs are absent. In other words, the two verb classes form a presence/absence contrast in the inversion construction. This input frequency contrast might enable children to break into the unaccusative-unergative distinction in Mandarin Chinese. In this study, we will report findings from two eye-fixation experiments that tested 19-month-old Mandarin-learning toddlers' sensitivity to the presence/absence contrast between familiar unaccusative verbs and unergative verbs in the inversion construction. To our knowledge, it is the first experimental study addressing issues involving the unaccusative-unergative distinction in infants at this young age. This study provides preliminary evidence for young children's sensitivity to language-specific input cues, laying ground for further investigations on acquisition mechanisms of unaccusativity.

The Unaccusative-unergative Distinction: Across Languages and in Child Language

Ever since Perlmutter (1978) proposed the *Unaccusative Hypothesis* based on impersonal passives in Dutch, theoretical linguists have found different encodings of the

unaccusative-unergative distinction cross-linguistically. Intrigued by the complexity of the phenomenon, acquisitionists have also carried out corpus and experimental studies to investigate children's knowledge of language-specific constructions that reflect the unaccusative-unergative distinction. It has been found that children are generally sensitive to the distinction in their native language. For instance, in some Romance and Germanic languages, the distinction manifests in auxiliary selection: unaccusative verbs usually select the auxiliary *BE*, while unergative verbs select *HAVE*. Snyder et al. (1995) found that two-to-three-year-old French and Italian children showed good mastery of auxiliary selection of *BE* and *HAVE* in spontaneous speech. In languages such as English, thematic roles of arguments are relevant to the unaccusative-unergative distinction. Generally speaking, only unaccusative verbs are tolerable with inanimate subjects but not unergative verbs, as inanimate participants are generally not compatible with the Agent role. The corpus analysis in Becker and Schaeffer (2013) found that children used animate subjects for unergative verbs predominantly (93.1%), but allowed unaccusative verbs to occur equally with both animate and inanimate subjects (51.5% and 48.5%, respectively). The asymmetry in the distribution of animate subjects indicates children's sensitivity to the argument structure of unaccusative and unergative verbs.

Among all the manifestations of the unaccusative-unergative distinction, the inversion construction is attested across languages, where the argument occurs post-verbally. Observe the Italian sentences in (4) to (6), for example. As can be seen in (4b) - (6b), subjects sometimes occur in the post-verbal position, forming a VS order. However, the inversion construction in Italian is not unitary (Burzio, 1986). For unergative verbs in (5b) and transitive verbs in (6b), only when the subject 'many experts' is focused can it occur post-verbally. In contrast, the subject 'many experts' in sentence (4b), which contains an unaccusative verb 'arrive', can occur post-verbally without pragmatic requirements. In other words, when the subject is not focused, only unaccusative verbs are permissible in the inversion construction.

(4) a. Molti   esperti   arriveranno. (Burzio, 1986, p. 21)
         many   experts   will arrive.
     b. Arriveranno molti esperti.
         will arrive   many experts.
         'Many experts will arrive.'

(5) a. Molti   esperti   telefoneranno.
         many   experts   will telephone.
     b. Telefoneranno molti   esperti.
         will telephone   many   experts.
         'Many experts will telephone.'

(6) a. Molti   esperti   esamineranno il   caso.
         many   experts   will example   the case.
     b. esamineranno il   caso   molti   esperti.
         will examine   the case   many   experts.
         'Many experts will examine the case.'

Acquisition studies manipulating word order show that children are sensitive to the different behavior of unaccusative and unergative verbs in the inversion construction. Friedmann and Costa (2011) tested two-to-four-year-old children of Hebrew, European

Portuguese, Palestinian Arabic, and Spanish using sentence repetition and story retelling tasks. In all the four languages, children had a good repetition and production performance with the inversion construction with unaccusative verbs. A similar task was adopted by Vernice and Guasti (2014), which observed that four-to-five-year-old Italian-learning children were also sensitive to the word order difference between unaccusative and unergative verbs. They demonstrated better accuracy in repeating the inversion construction "V NP" with unaccusative verbs than with unergative verbs. Besides, children were more likely to change a "V NP" unergative sentence into the "NP V" order than they did with unaccusative sentences. Such facts suggest that children's sensitivity to word order is related to unaccusative versus unergative verbs.

In sum, the unaccusative-unergative distinction is manifested in language-specific constructions in one way or another. Longitudinal and experimental studies show an overall sensitivity of children learning different languages to the distinction from an early stage. In most cases, children successfully learn the language-specific manifestations of the unaccusative-unergative distinction before school age.

How does the learning take place? Different forces may come into play, such as input cues drawn from the linguistic environment. For children acquiring a certain language, various forms or constructions manifesting the unaccusative-unergative distinction might help distinguishing the two verb classes in that target language. For example, the fact that some verbs occur with marker X while other verbs with marker Y might act as morphological cues that lead to the preliminary categorization of verb classes. Distributional cues, e.g., the presence/absence contrast in certain constructions, could also hint to child learners that there exist two different types of intransitive verbs. In fact, previous studies on verb learning have found that children are sensitive to frequency contrasts in the input, and that they employ the presence/absence of verbs in certain constructions to learn the syntactic performance of verbs as well as constrain the process of generalization (e.g., Akhtar, & Tomasello, 1997; Ambridge, Barak, Wonnacott, Bannard, & Sala, 2018; Braine, Brody, Fisch, Weisberger, & Blum, 1990; Brooks, & Tomasello, 1999; Conwell, & Demuth, 2007; Gropen, Pinker, Hollander, Goldberg, & Wilson, 1989; Kline, & Demuth, 2014; Yang, 2016; among many others). For example, Ambridge et al. (2018) revealed a correlation between the presence/absence of verbs (measured based on the *chi*-square test) in dative and locative constructions in adult input and children's overgeneralization errors of verb argument structure observed in judgment tasks. It is possible that similar learning processes happen during the acquisition of the unaccusative-unergative distinction as well, and that children use input cues specific to their native language to learn the difference between the two verb classes.

Before discussing what cues might play a role in the acquisition of unaccusatives and unergatives in Mandarin Chinese, we first introduce the facts on unaccusativity in Mandarin, as well as previous acquisition findings.

Unaccusativity in Mandarin Chinese

Typologically, Mandarin Chinese is an isolating language with no overt morphological markers (Li, & Thompson, 1989). Grammatical morphemes (case markers, clitics, etc.) marking the unaccusative-unergative distinction seen in many other languages are not found in Mandarin. For such a language, word order becomes a powerful tool in expressing grammatical relations. As an SVO language, both unaccusative and unergative verbs can occur in the canonical "NP V" order (cf. (7)).

(7) a. Unaccusative
    keren   lai   le
    guest   come   *LE* (LE=perfective aspect marker)
    'The guest(s) came.'
  b. Unergative
    haizi   ku   le
    kid   cry   *LE*
    'The kid(s) cried.'[1]

The inversion construction, in a non-canonical word order, only applies in a limited range of circumstances, which is considered relevant to the unaccusative-unergative distinction (Hu, 2008; Huang, 1987; Lu, & Lee, 2020; Lü, 1987; Pan, & Han, 2008; Wen, & Chen, 2001; Xu, 1999). A typical inversion construction in Mandarin consists of a locative phrase, a verb, an aspect marker, and a noun phrase. With the presence of perfective aspect marker *le*, unaccusative verbs can take post-verbal NPs as in (8).

(8) jia-li   lai   le   liang-ge   keren
    home-in come *LE* two-CL   guest   (CL=classifier)
    'Two guests came to our house.'

In some cases, unergative verbs seem to enter the inversion construction as well (see (9)). However, specific and strict context requirements need to be satisfied for an unergative verb to enter into the inversion construction (see Liu (2009) for the pragmatic requirements).

(9) youeryuan   ku   le   san-ge   haizi
    kindergarten cry *LE* three-CL kid
    'In the kindergarten, there were three kids who cried.'

When we remove the preverbal locative phrase which offers contextual information, the "bare" inversion construction "V-*le* NP" can be a reliable indicator of the unaccusative-unergative distinction, as shown in (10). In a "V-*le* NP" construction, sentences with unaccusative verbs are still grammatical (cf. (10a)), while sentences with unergative verbs are ungrammatical (cf.10b).

(10) a. lai   le   liang-ge   keren
      come LE two-CL   guest
      'Two guests came.'
   b. *ku   le   san-ge   haizi
      cry   LE three-CL kid
      Intended meaning: 'Three kids cried.'

Note that in (8) and (10a), the post-verbal argument of unaccusative verbs is indefinite. This definiteness effect has been observed and analyzed in existential sentences by many

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[1]In Mandarin, bare nouns can be interpreted as definite or indefinite depending on the context. In (7), the two bare nouns *keren* 'guest' and *haizi* 'kid' are in the preverbal position, so they receive a definite interpretation. As bare nouns do not specify the number feature, the English translation could be either *the guest/kid* or *the guests/kids*.

linguists (e.g., Safir, 1982; among others), where only indefinite NPs can occur in the *there*-construction, a typical inversion construction in English. Huang (1987) argues that it also holds in inversion constructions with unaccusative verbs in Mandarin, especially for unaccusative verbs that have to do with "coming into existence" (e.g., *lai* 'come', *fasheng* 'happen') and "going out of existence" (e.g., *si* 'die', *xiaoshi* 'disappear'). The "numeral + CL + N" construction in (8a) is normally indefinite in Mandarin (Chen, 1987), and thus is allowed to occur after the unaccusative verb *lai* 'come'; on the other hand, the definite NP in (11b) with demonstrative *zhe* 'this' results in ungrammaticality.

(11) a. lai   le   liang-ge   keren
          come   *LE*   two-CL   guest
          'Two guests came.'
      b. *lai   le   zhe-ge   keren
          come   *LE*   this-CL   guest
          Intended meaning: 'This guest came.'

Some other diagnostics have been proposed for unaccusativity in Mandarin as well, including quantifier stranding (e.g., Sung, 1994; Yu, 1995), aspect particle selection (perfective *le* vs. progressive *zhe*; e.g., Hu, 1995; Liu, 2007; Yu, 1995), causative alternation (similar to *break* in English; e.g., Lü, 1987; Zeng, 2007), and semantic features (telicity and mode of causation, e.g., Lu, 2019). Typical unaccusative verbs are usually telic. They also allow quantifier stranding, select perfective aspect *le*, and allow causative alternation in most cases (see Lu, & Lee, 2020 for details).

To our knowledge, there are only a few studies investigating the acquisition of unaccusativity in Mandarin Chinese. Experimental explorations have found that pre-school children show adult-like understanding in terms of quantifier stranding constructions as well as semantic features (telicity and mode of causation) (Lu, 2019). Mandarin-speaking children are sensitive to the unaccusative-unergative distinction just like their peers from other language backgrounds.

Observational studies also suggest that children's early production of inversion constructions seems to differ between unaccusative and unergative verbs. Li (2008) carried out a preliminary corpus analysis of two Mandarin-speaking children's longitudinal production of unaccusative verbs and their arguments from the BJCELA corpus.[2] The two children started to produce unaccusative verbs before 1;5 (e.g., *dao* 'arrive', *meiyou* 'disappear'), which were among the first few words uttered. After using bare verbs for some time, they began to produce arguments along with them. Lu (2019) further observed that unaccusative verbs were first produced with a post-verbal argument (i.e., an inversion construction) between 1;6;16 and 1;8;27.[3] The frequencies of unaccusative verbs taking a post-verbal argument ranged from 29.17% to 48.39% (measure in type) among

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[2]The corpus was built as part of a Chinese early language project led by Prof. Thomas Lee at the Chinese University of Hong Kong. The corpus consists of longitudinal naturalistic data of four Beijing-born children with the first observation starting when the children were around age 1. Each child was visited weekly or bi-weekly at home and an audio/video recording session was taken during each visit of the non-structured natural interactions between the child and the adults (including the investigators). Each session was approximately one hour long.

[3]Lu (2019) examined three of the four children in the corpus. Age rage: CY 0;10;05-2;04;31, SJQ 1;02;06-1;11;29, ZTX 0;11;18-2;06;02. She further conducted a series of experiments with older children (four-to-six-year-olds). The experimental explorations offer a clear picture of pre-school children's knowledge of

the three children investigated, roughly consistent with those in adult input (26.09% - 27.03%). Unergative verbs, on the other hand, were rarely seen in the inversion construction either in adult input or in child output. In fact, "V NP" utterances containing unergative verbs were completely absent in adult input, and only constituted 3.23% (measure in type) of unergative uses in child production.

The corpus studies have provided information about both adult input and child production of the inversion construction: the presence/absence contrast between the two verb classes in the inversion construction is attested in adult input, and children's production also indicates some level of differentiation before age 2;6. It is not a surprise that children show a similar pattern with adults, as prior studies have found early sensitivity to both canonical and non-canonical word order in Mandarin-speaking children. They display an emerging understanding of the canonical SVO order as young as 17 months old (Candan, Küntay, Yeh, Cheung, Wagner, & Naigles, 2012; Zhu, Franck, Rizzi, & Gavarró, 2021), and are able to productively use sentences of non-canonical word order in their spontaneous speech before age two (Fan, & Song, 2016). Findings from Lu (2019) further reveal that children's sensitivity to word order can be used as an indicator of their knowledge of verbs. However, production does not always reflect children's comprehension knowledge. Specifically, the very low percentage of inversion constructions with unergative verbs in children's spontaneous production might have multiple causes, and does not necessarily mean that they know unergative verbs are not allowed in the inversion construction. In order to probe into children's knowledge of verb distribution in the inversion construction, it is necessary to conduct experimental studies where inversion constructions with unaccusative verbs and unergative verbs are compared directly. If young children are able to distinguish inversion constructions containing the two verb classes when hearing them, it is reasonable to infer that they know what verbs are allowed in the inversion construction, i.e., the presence/absence contrast. Therefore, in the present study, we used experimental methods to test whether young children differentiate inversion constructions containing unaccusative verbs and unergative verbs. For consistency, we chose 19-month-old Mandarin-learning toddlers as participants, roughly the same age when they started to produce verbs in the inversion construction.

It is difficult to engage very young participants in tasks used in prior studies reviewed in the last section, so the earliest age tested experimentally was two years (Friedmann, & Costa, 2011). In the current study, we adopted the eye fixation task instead. This task examines children's natural looking/listening behavior: they simply watch and listen to a cartoon character speaking the auditory stimuli, free to turn away from the screen when they lose interest. They are not required to point or answer questions verbally. The low requirement on participants' responsive abilities makes it a good method to test speech perception and language comprehension (including intuitive grammaticality judgment) in infants and toddlers. Previous studies have used the method to test phonemic and phonetic discrimination (e.g., Burns, Yoshida, Hill, & Werker, 2007), word-object association (e.g., Werker, Cohen, Lloyd, Casasola, & Stager, 1998), the acquisition of functional morphemes (e.g., Marquis, & Shi, 2012), novel word categorization (e.g., Zhang, Shi, & Li, 2015), phrase structure analysis (Massicotte-Laforge, & Shi, 2020; Shi, Legrand, & Brandenberger, 2020) and so on in infants and toddlers. Seen in this light, we believe that the eye fixation task is appropriate for the objective of the current study – that is, to

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unaccusativity: they have shown adult-like understanding in terms of quantifier stranding constructions as well as semantic features (telicity and mode of causation) under investigation.

test whether toddlers distinguish inversion constructions containing unaccusative verbs and those containing unergative verbs. Significant differences in looking times between the two types of test trials would be taken as evidence for children's distinguishing behavior.

Two experiments were conducted in the present study. In Experiment 1, we tested whether participants were able to differentiate the inversion construction "V-*le* NP" containing familiar unaccusative and unergative verbs, by measuring their looking times in two types of test trials consisting of minimal pair sentences. To rule out the possible confounding factor of verb item frequencies, Experiment 2 was conducted with the same verb items in the canonical word order "NP V-*le*", where verb classes did not affect grammaticality.

Experiment 1

Participants

Participants were 24 monolingual Mandarin-learning 19-month-old infants (mean age: 608 days, range: 1;6;30-1;8;24, 12 boys), with no hearing problems or language disorders reported. Before the experiment, informed consent was obtained from the parents. Participants' knowledge of the words used in the test was examined through a questionnaire filled by their caretakers after the experiment. Those who were able to understand the words (both the verbs and the nouns) used in the test would be taken as valid participants. Based on the questionnaire, all infants knew the words used in our speech stimuli. The data of another 8 infants were excluded due to fussiness (4), ceiling looking (3), and parent interference during test (1).

Stimuli and Design

Speech stimuli included four verbs: two unaccusative verbs *lai* 'come' and *diao* 'fall', and two unergative verbs *ku* 'cry' and *xiao* 'laugh'. The four verbs are all commonly used in adult input, and thus are familiar to children before the age of two.

The two unaccusative verbs were selected using the structural and semantic diagnostics for intransitive verbs in Mandarin, as discussed in the previous section. The verbs *lai* 'come' and *diao* 'fall' are typical unaccusative verbs in Mandarin: structurally, they can both occur in the inversion construction with the perfective aspect marker *le*; semantically, they are both telic. On the other hand, *ku* 'cry' and *xiao* 'laugh' do not pass those unaccusativity tests, and are unergative verbs.

Test sentences were inversion constructions, in the form of "V + LE + numeral-CL + N". As mentioned in the last section, sentences in such a form are grammatical with unaccusative verbs and ungrammatical with unergative verbs. See (12a) and (12b) for examples of each type of test sentences. Nouns occurring in the test sentences were names of animals that are common in early child-directed language, so that infants could process the sentence without much burden.

(12) a. Unaccusative sentences (grammatical)
          lai   le   yi-zhi   daxiang
          come   *LE*   one-CL   elephant
          'An elephant came.'

   b.   Unergative sentences (ungrammatical)
        *xiao   le   yi-zhi   daxiang
         laugh   *LE*   one-CL   elephant
        Intended meaning: 'An elephant laughed.'

A female native Mandarin speaker recorded the stimuli in a child-directed manner. In order to avoid unnatural intonation of ungrammatical sentences, all stimuli were recorded and edited with the method of splicing. Specifically, each stimulus sentence (either grammatical or ungrammatical) was part of a longer grammatical sentence when being recorded. For example, the ungrammatical (13a) and grammatical (14a) stimuli were spliced out of the recorded longer grammatical sentences (13b) and (14b). In this way, all the stimuli came from grammatical sentences, so that no unnatural acoustic characteristics or disfluency would be produced due to the ungrammatical sentences. The recorded sentences shared the same prosodic pattern (i.e., duration, rhythm, etc.).

(13)   a.   *ku   le   yi-zhi   xiaogou
             cry   *LE*   one-CL   dog
             Intended meaning: 'A dog cried.'
       b.   ciwei   xia   ku   le   yi-zhi   xiaogou
             hedgehog   frighten   cry   LE   one-CL   dog
             'The hedgehog frightened a dog into crying.'

(14)   a.   diao   le   yi-zhi   xiaogou
             fall   *LE*   one-CL   dog
             'A dog fell.'
       b.   laohu   chi   diao   le   yi-zhi   xiaogou
             tiger   eat   up   LE   one-CL   dog
             'The tiger ate up a dog.'

In all, the stimuli contained 32 test sentences, 8 sentences for each of the four verbs. Sentences with the same verb formed the sound file of a test trial, and thus there were four sound files in total – namely, two unaccusative ones (*lai* 'come' trial and *diao* 'fall' trial) and two unergative ones (*ku* 'cry' trial and *xiao* 'laugh' trial). Within each trial, all the sentences shared the same sentence pattern and the same verb, but differed in NPs. In this way, a moderate amount of variability could keep the infants on task while the consistency of verb and sentence pattern avoided distraction and drew their attention to the target structure.

We created an animation of a talking puppet, which was played on the screen along with the sentences during the test trials. Her mouth opened and closed in synchrony with the speech, as if she was uttering the test sentences. Between test trials, the video of a spinning windmill together with a piece of light music served as the attention getter.

Participants were divided into two groups. Half of the children listened to the unaccusative *lai* ('come') test trial and the unergative *xiao* ('laugh') test trial, while the other half listened to the unaccusative *diao* ('fall') test trial and the unergative *ku* ('cry') test trial. This way, each participant heard one unaccusative verb and one unergative verb. Verbs in the same group (e.g., unaccusative *lai* 'come' and unergative *xiao* 'laugh') took the same set of numeral phrases and nouns, so that for each group, the only difference

between grammatical trials and ungrammatical trials was in the verb itself (see Table 1). The maximum length of each trial was around 24.1 s, with an inter-stimulus interval (between sentences) of 1.25 s.

The rationale for dividing participants into two groups was that we wanted to test whether participants would respond to different verb items within the same verb class (e.g.,unaccusative *lai* 'come' and *diao* 'fall') similarly. Though verb items belonging to the same verb class have similar syntactic behavior in our test sentences, a search in BJCELA corpus showed that their general token frequencies in adult input differed: before 1;8, the token frequencies of unaccusative verbs *lai* 'come' and *diao* 'fall' were 8001 and 560 respectively, while those of unergative verbs *xiao* 'laugh' and *ku* 'cry' were 365 and 260 respectively. Frequency contrasts exist in both verb classes, especially within the unaccusative class. In dividing participants into *lai-xiao* Group and *diao-ku* Group, we could compare the performance of the two groups to see whether verb item frequency plays a role in the experiment. The presence of a grammaticality effect without any effect of verb item frequency would be evidence in support of the idea that the two unaccusative verbs (and likewise, the two unergative verbs) are treated as belonging to the same class.

All participants were presented with unaccusative (grammatical) trials and unergative (ungrammatical) trials in alternation for a maximum of 12 trials (6 for each type of trials). The order of the first trial was also counterbalanced, so that half of the participants listened to the unaccusative trial as the first trial while the other half listened to the unergative trial as the first trial.

Procedure

During the test, the infant sat on the parent's lap in front of a TV in a dimly lit acoustic booth. The visual stimuli were presented on the TV screen, and the auditory stimuli were played through loudspeakers on both sides of the TV. During the whole experiment, the parent wore headphones that played masking music so that he or she could not guide the child's looking behavior. He/she was also told beforehand not to talk to the infant or direct the infant's attention. The experimenter, who was blind to all stimuli, was in another room observing the children's looking performance on a monitor, which was connected to a video camera hidden under the display screen in the test room.

This experiment was run with an in-house computer program. The procedure was infant-controlled: all trials were started when children looked at the screen, and ended when they looked away for over 2s or when the full trial length of 24.1 s was played. Whenever the child looked at the TV screen, the experimenter pressed down a computer key, and the looking time was automatically recorded by the computer program for later analysis.

Predictions

It was predicted that if infants knew that unaccusative and unergative verbs behave differently in inversion constructions, their looking time should be different for unaccusative trials (grammatical) versus for unergative trials (ungrammatical). Moreover, we made predictions consistent with our hypothesis that participants would treat verb items within the same verb class similarly despite the frequency contrasts found in the input (*lai* vs. *xiao*: 8001 vs. 365; *diao* vs. *ku*: 560 vs. 260): looking time in the two unaccusative trials (*lai* trials and *diao* trials) should be similar, and looking time in the two unergative trials

Table 1. Test stimuli and design of Experiment 1

lai-xiao Group (*lai* 'come' vs. *xiao* 'laugh')							
(Form: Verb LE numeral-CL N)							
Unaccusative trial (grammatical)				Unergative trial (ungrammatical)			
lai (come)	*le* (LE)	*yi-zhi daxiang*	(one-CL elephant)	*xiao* (laugh)	*le* (LE)	*yi-zhi daxiang*	(one-CL elephant)
lai	*le*	*wu-zhi shanyang*	(five-CL goats)	*xiao*	*le*	*wu-zhi shanyang*	(five-CL goats)
lai	*le*	*yi-qun qi'e*	(one-CL penguins)	*xiao*	*le*	*yi-qun qi'e*	(one-CL penguins)
lai	*le*	*san-zhi laohu*	(three-CL tigers)	*xiao*	*le*	*san-zhi laohu*	(three-CL tigers)
lai	*le*	*liu-zhi mifeng*	(six-CL bees)	*xiao*	*le*	*liu-zhi mifeng*	(six-CL bees)
lai	*le*	*ji-zhi huli*	(several-CL foxes)	*xiao*	*le*	*ji-zhi huli*	(several-CL foxes)
lai	*le*	*si-zhi shizi*	(four-CL lions)	*xiao*	*le*	*si-zhi shizi*	(four-CL lions)
lai	*le*	*liang-zhi xiongmao*	(two-CL pandas)	*xiao*	*le*	*liang-zhi xiongmao*	(two-CL pandas)
diao-ku Group (*diao* 'fall' vs. *ku* 'cry')							
(Form: Verb LE numeral-CL NP)							
Unaccusative trial (grammatical)				Unergative trial (ungrammatical)			
diao (fall)	*le* (LE)	*yi-zhi xiaogou*	(one-CL dog)	*ku* (cry)	*le* (LE)	*yi-zhi xiaogou*	(one-CL dog)
diao	*le*	*san-zhi yazi*	(three-CL ducks)	*ku*	*le*	*san-zhi yazi*	(three-CL ducks)
diao	*le*	*ji-zhi xiaoniao*	(several-CL birds)	*ku*	*le*	*ji-zhi xiaoniao*	(several-CL birds)
diao	*le*	*liang-zhi qingwa*	(two-CL frogs)	*ku*	*le*	*liang-zhi qingwa*	(two-CL frogs)
diao	*le*	*san-zhi tuzi*	(three-CL rabbits)	*ku*	*le*	*san-zhi tuzi*	(three-CL rabbits)
diao	*le*	*ji-zhi xiaomao*	(several-CL cats)	*ku*	*le*	*ji-zhi xiaomao*	(several-CL cats)
diao	*le*	*yi-zhi laoshu*	(one-CL rat)	*ku*	*le*	*yi-zhi laoshu*	(one-CL rat)
diao	*le*	*liang-zhi xiaoji*	(two-CL chickens)	*ku*	*le*	*liang-zhi xiaoji*	(two-CL chickens)

(*xiao* trials and *ku* trials) should be similar as well. Note that two directions of looking preference were possible in the eye fixation task. A familiarity effect would be the pattern with a longer looking time in grammatical trials, while a novelty effect would be the opposite: a longer looking time in ungrammatical trials. Either direction of preference in this task indicates a discrimination of different types of trials. The direction of preference was not predictable for our experiment, but either a familiarity effect or a novelty effect would suggest children's discrimination of the two types of trials. If, however, they could not distinguish inversion constructions containing the two types of verbs, there should be no significant difference in terms of their looking time in unaccusative versus unergative trials.

Results

For each child participant, the average looking time of grammatical trials and that of ungrammatical trials were calculated. Given the test design, we compared children's mean looking times in grammatical trials (with unaccusative verbs) and that in ungrammatical trials (with unergative verbs) to see whether they distinguished the two verb classes. Overall, looking time to ungrammatical trials was longer (*Mean*: 14.515 s, *SE* = 0.783) than to grammatical trials (*Mean*: 12.292 s, *SE* = 0.804), as shown in Figure 1. Paired *t*-test results show that there was a significant difference in looking time between these two verb types ($t(23) = -2.536$, $p = .018$, two-tailed, Cohen's d = 0.518). This indicates that our participants treated inversion constructions containing unaccusative verbs differently from those containing unergative verbs. As for the direction of preference, it is possible that inversion constructions with unaccusative verbs sounded normal to them whereas inversion constructions with unergative verbs were odd, consistent with the presence/absence contrast found in the input. The novelty looking preference suggests that our infants were surprised to hear the odd sentences as opposed to the normal ones.

As participants were divided into two groups which differed in verb items, we further conducted a 2*2 ANOVA to assess whether different verb items influenced their looking
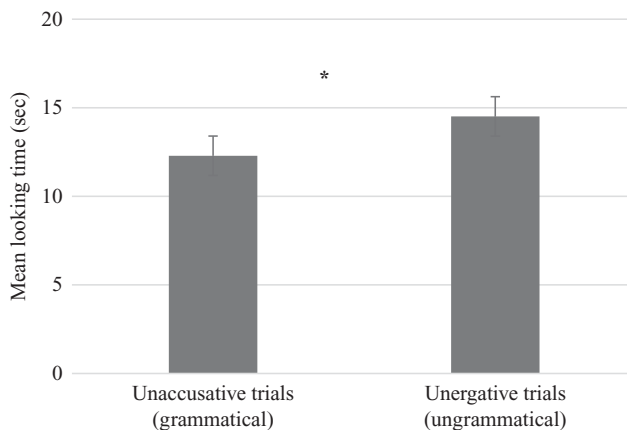

Figure 1. Mean looking time of unaccusative trials and unergative trials in Experiment 1
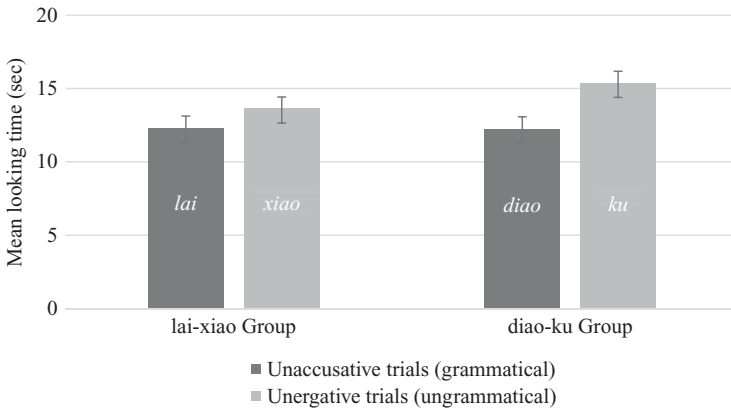
Figure 2. Mean looking time of unaccusative and unergative trials in *lai-xiao* Group and *diao-ku* Group in Experiment 1

behavior. The within-subject factor was Verb Class (unaccusative vs. unergative), and the between-subject factor was Group (*lai-xiao* Group vs. *diao-ku* Group). See Figure 2 for results of the two groups. A significant main effect was found for Verb Class ($F(1, 23) =$ 4.952, $p = .038$, $\eta^2 = 0.079$), consistent with the results of the paired t-test. However, there was no significant main effect of Group ($F(1, 23) = 0.32$, $p = .578$). Importantly, the interaction between Verb Class and Group was not significant ($F(1, 23) = 0.597$, $p = .449$). That is, there was no evidence that the discrimination pattern differs between the *lai-xiao* group and the *diao-ku* group. The direction of preference is uniform: in both groups, infants looked longer in ungrammatical trials. These results demonstrate that there was no evidence that children treated items within the same verb class differently despite their differential frequencies in the input.

Discussion

The results in this experiment provide evidence that 19-month-old toddlers are able to distinguish inversion constructions containing unaccusative verbs from inversion constructions containing unergative verbs. Specifically, in the experiment, they seemed to treat *lai* 'come' and *diao* 'fall' as a single class, and realized that they had different behavior in inversion constructions than the other class, *xiao* 'laugh' and *ku* 'cry'. However, another frequency factor might have played a role in the experiment: the general token frequencies of the two unaccusative verbs (*lai* 'come': 8001; *diao* 'fall': 560) were much higher than those of the two unergative verbs (*xiao* 'laugh': 365; *ku* 'cry': 260). It is possible that participants simply tracked these verb frequencies in the input regardless of sentence structures, and distinguished the two types of trials merely based on the frequency contrast of the verbs. The preference of the two unergative trials might be due to the fact that the two verb items *xiao* 'laugh' and *ku* 'cry' were less frequent and thus fresher and more attractive to them. In other words, the different looking behavior might not come from grammaticality contrast between the two types of trials. To test whether participants only paid attention to frequency contrast of verb items, we carried out Experiment 2, in which the grammaticality factor was removed.

Experiment 2

Participants

24 19-month-old Mandarin-learning toddlers (mean age: 599 days, range: 1;6;20-1;8;29, 9 boys) participated in Experiment 2. The data of another 5 infants were excluded due to fussiness (2), and ceiling looking (3). The same questionnaire was given to caretakers after each testing session, which showed that all infants knew the words used in our stimuli.

Stimuli and Design

In Experiment 2, we changed the word order into the canonical "NP V-*le*", keeping everything else the same as in the previous experiment. For the inversed "V-*le* NP" order used in our previous experiment, there was a clear contrast in grammaticality between unaccusative and unergative verbs. With the change in word order, both sentence types containing unaccusative verbs and unergative verbs had the same level of grammaticality, as shown in (15).

(15) a. Unaccusative sentences
          yi-zhi   daxiang   lai   le
          one-CL   elephant   come   LE
          'An elephant came.'
      b. Unergative sentences
          yi-zhi   daxiang   xiao   le
          one-CL   elephant   laugh   LE
          'An elephant laughed.'

According to our intuition as native speakers, test sentences (12) in Experiment 1 formed a grammaticality contrast, while test sentences (15) in Experiment 2 did not. To make sure that our intuition is reflected in the input, we carried out a corpus analysis to see how the four verb items behave in the inversion construction "V-*le* NP" and the canonical order "NP V-*le*". As shown in Table 2, only the two unaccusative verbs were found in the inversed order. In contrast, both verb classes occurred in the canonical order, with unaccusative verbs having relatively higher frequencies. This input pattern conforms to our intuition that unaccusative verbs and unergative verbs form a grammaticality contrast in "V-*le* NP" constructions, but not in "NP V-*le*".

Some native speakers may find sentences in (15) degraded. Adding the existential verb *you* 'exist' at the beginning of the sentence improves acceptability below.

(16) a. Unaccusative sentences
          you   yi-zhi   daxiang   lai   le
          exist   one-CL   elephant   come   LE
          'There was an elephant that came.'

Table 2. Verb frequencies in specific constructions "V-*le* NP" and "NP V-*le*"

Verb Class	Unaccusative (*lai* + *diao*)	Unergative (*xiao* + *ku*)
Tokens in "V-*le* NP" construction	19	0
Tokens in "NP V-*le*" construction	163	77

b. Unergative sentences
you   yi-zhi   daxiang   xiao   le
exist   one-CL   elephant   laugh   LE
'There was an elephant that laughed.'

The contrast between (15) and (16) reflects the phenomenon that indefinite nominal expressions generally are less natural in subject or topic position in Mandarin (see Chao, 1968; Li, & Thompson, 1989; among many others). In Experiment 2, we did not add *you* to the sentence for the following reasons. First, (15) forms a minimal pair with (12) in the previous experiment, with only a change in word order. In this way, we could focus on whether participants were sensitive to the word order distinction. Moreover, even if less acceptable than sentences in (16), (15a) and (15b) do not differ in grammaticality, which satisfies our needs: to test whether verb preference exists when the two sentences are equal in grammaticality.

As all the test sentences had the same level of grammaticality, we did not use the splicing method for recording. The trial length and inter-stimulus interval were the same as those in the previous experiment: each trial was around 24.1 s, with an interval (between sentences) of 1.25 s. The design and procedure were the same as Experiment 1 (see Table 3).

If our child participants were biased by verb frequencies, looking times in the unaccusative trials and unergative trials should differ, just as in Experiment 1. On the contrary, if their looking behavior reflected judgment of well-formedness of the sentences, looking times would not differ between trials as both had the same level of grammaticality. In this case, we expect to find a cross-experiment difference between results of Experiment1 and Experiment 2.

Results

Contrary to Experiment 1, no differential preference for the two types of verbs in the "NP V-*le*" sentences was found: a paired *t*-test showed no significant difference in looking time ($t(23)$ = -0.383, p = .705, two-tailed) between unaccusative trials (*Mean*: 15.010 s, SE = 0.803) and unergative trials (*Mean*: 15.271 s, SE = 0.680). See Figure 3 for the mean looking times in Experiment 2.

As in Experiment 1, a two-way ANOVA was conducted. The within-subject factor was Verb Class (unaccusative vs. unergative), and the between-subject factor was Group (*lai-xiao* group vs. *diao-ku* group). There was no significant main effect of either Verb Class (F(1, 23) = 0.142, p = .71) or Group (F(1, 23) = 0.168, p = .686). No interaction between Verb Class and Group was found (F(1, 23) = 0.148, p = .704). Since there was no grammaticality contrast between the unaccusative class and the unergative class in the canonical "NP V-*le*" sentences, we interpreted the results as indicating that there was no evidence that participants treated the four verbs differently in Experiment 2.

To confirm that children in the two experiments had different looking patterns, we further conducted a cross-experiment ANOVA. The within-subject factor was Verb Class (unaccusative vs. unergative), and the between-subject factor was Experiment (Exp.1 vs Exp. 2). A marginal interaction was found between Verb Class and Experiment (F(1, 46) = 3.121, p = .084, η^2 = 0.016). These results suggest a distinction, albeit a weak one, in looking responses between the two experiments: participants distinguished the two trial types in Experiment 1, but there was no evidence that the trial types were distinguished in Experiment 2.

Table 3. Test stimuli and design of Experiment 2

| *lai-xiao* Group (*lai* 'come' vs. *xiao* 'laugh')							
(Form: numeral-CL N Verb LE)							
Unaccusative trial				Unergative trial			
yi-zhi daxiang	(one-CL elephant)	*lai* (come)	*le* (LE)	*yi-zhi daxiang*	(one-CL elephant)	*xiao* (laugh)	*le* (LE)
wu-zhi shanyang	(five-CL goats)	*lai*	*le*	*wu-zhi shanyang*	(five-CL goats)	*xiao*	*le*
yi-qun qi'e	(one-CL penguins)	*lai*	*le*	*yi-qun qi'e*	(one-CL penguins)	*xiao*	*le*
san-zhi laohu	(three-CL tigers)	*lai*	*le*	*san-zhi laohu*	(three-CL tigers)	*xiao*	*le*
liu-zhi mifeng	(six-CL bees)	*lai*	*le*	*liu-zhi mifeng*	(six-CL bees)	*xiao*	*le*
ji-zhi huli	(several-CL foxes)	*lai*	*le*	*ji-zhi huli*	(several-CL foxes)	*xiao*	*le*
si-zhi shizi	(four-CL lions)	*lai*	*le*	*si-zhi shizi*	(four-CL lions)	*xiao*	*le*
liang-zhi xiongmao	(two-CL pandas)	*lai*	*le*	*liang-zhi xiongmao*	(two-CL pandas)	*xiao*	*le*
diao-ku Group (*diao* 'fall' vs. *ku* 'cry')							
(Form: numeral-CL N Verb LE)							
Unaccusative trial				Unergative trial			
yi-zhi xiaogou	(one-CL dog)	*diao* (fall)	*le* (LE)	*yi-zhi xiaogou*	(one-CL dog)	*ku* (cry)	*le* (LE)
san-zhi yazi	(three-CL ducks)	*diao*	*le*	*san-zhi yazi*	(three-CL ducks)	*ku*	*le*
ji-zhi xiaoniao	(several-CL birds)	*diao*	*le*	*ji-zhi xiaoniao*	(several-CL birds)	*ku*	*le*
liang-zhi qingwa	(two-CL frogs)	*diao*	*le*	*liang-zhi qingwa*	(two-CL frogs)	*ku*	*le*
san-zhi tuzi	(three-CL rabbits)	*diao*	*le*	*san-zhi tuzi*	(three-CL rabbits)	*ku*	*le*
ji-zhi xiaomao	(several-CL cats)	*diao*	*le*	*ji-zhi xiaomao*	(several-CL cats)	*ku*	*le*
yi-zhi laoshu	(one-CL rat)	*diao*	*le*	*yi-zhi laoshu*	(one-CL rat)	*ku*	*le*
liang-zhi xiaoji	(two-CL chickens)	*diao*	*le*	*liang-zhi xiaoji*	(two-CL chickens)	*ku*	*le*
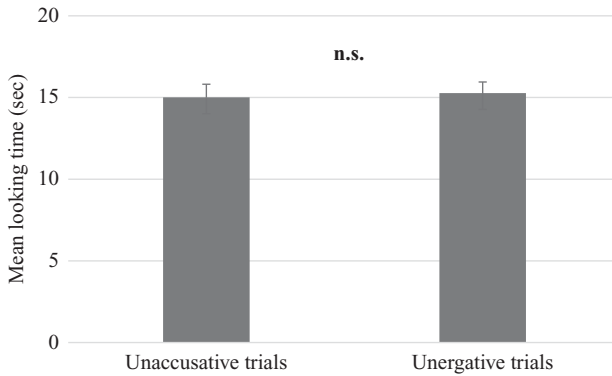
Figure 3. Mean looking time in unaccusative and unergative trials in Experiment 2

Discussion

In Experiment 2, 19-month-old toddlers showed comparable looking time for unaccusative and unergative sentences in the canonical "NP V-*le*" order. Compared with Experiment 1, the four verb items remained the same, but the grammaticality contrast was removed. Though the frequency difference between the four unaccusative and unergative verb items still existed, infants no longer treated the two types of sentences differently. Therefore, infants' looking responses in our experiments were based on their judgment of well-formedness of the test sentences, rather than the token frequency difference between the two verb classes in the input. Moreover, despite the higher frequencies of the two unaccusative verbs in the "NP V-*le*" order in the input (see Table 2), there is no evidence that our participants treated the two trial types differently, which have the same level of grammaticality. Therefore, the frequency contrast between the two verb classes in specific constructions cannot account for the looking patterns either. Our initial interpretation of the findings in Experiment 1 holds: children did distinguish inversion constructions containing unaccusative verbs and inversion constructions containing unergative verbs in Mandarin, and neither the general token frequencies of the four verbs nor the token frequencies in specific constructions played a role.

General Discussion

This study aimed at investigating whether 19-month-old Mandarin-learning toddlers are sensitive to the presence/absence contrast of the two types of intransitive verbs in the inversion construction in Mandarin. Eye fixation tasks were adopted to test whether participants distinguished inversion constructions containing unaccusative and unergative verbs. In Experiment 1, we measured participants' looking/listening time to grammatical trials with unaccusative verbs and ungrammatical trials with unergative verbs, both in the form of "V-*le* NP". It was found that 19-month-old toddlers exhibited differential looking behavior in unaccusative and unergative trials: looking time during unergative trials was significantly longer than that during unaccusative trials. In Experiment 2 with the same verbs in a different word order in the form of "NP V-*le*", where unaccusative and unergative sentences had the same level of grammaticality, children no

longer showed differential looking behavior in the two types of trials. Although corpus analyses show that the unaccusative and unergative verbs used in our experiments have distinct frequencies in the input, with the former being higher than the latter, our participants' looking patterns were unlikely to be driven by the frequency contrasts between the two kinds of verb items. Taking results of the two experiments together, we found that children were sensitive to what environment the two verb classes could occur in. They recognized different behavior between unaccusative verbs and unergative verbs in the inversion construction "V-*le* NP". Without any help of overt morphological markers as salient cues, the presence/absence of the two verb classes in the inversion construction might be a cue for Mandarin-learning children to break into the unaccusative-unergative distinction.

Besides, we found no significant difference in looking time between verb items within the same verb class in both experiments: looking patterns in *lai-xiao* group and *diao-ku* group were similar. Though the two verb items within each verb class differ in token frequency in the input, frequency effects did not show in our participants' looking responses. It is not clear, however, whether they can systematically categorize intransitive verbs into two classes, as the number of verbs in our test stimuli was quite limited. Further studies with more verb items are needed to investigate their ability to categorically distinguish unaccusative and unergative verbs.

Findings from the current study are consistent with those from previous acquisition studies of unaccusativity that test the inversion construction in older children. In sentence repetition experiments (e.g., Friedmann, & Costa, 2011; Vernice, & Guasti, 2014), for instance, children behave differently in the repetition of "V NP" order sentences with unaccusative verbs and those with unergative verbs. Our study yields similar findings: participants showed different looking responses when listening to "V-*le* NP" order sentences containing the two verb classes. Thus, children learning different languages develop sensitivity to the distribution of the two verb classes in the inversion structure. Our experiment also extends the age of observation of this sensitivity to toddlers as young as 19 months, when productions are just moving toward the two-word stage.

In terms of the acquisition of unaccusativity, our experimental data also conforms to the naturalistic data in Mandarin (Li, 2008; Lu, 2019). Corpus studies have found that children produce inversion constructions with unaccusative verbs but hardly with unergative verbs. In our experiments, they were able to distinguish inversion constructions containing the two verb classes. With the two sides taken together, it is reasonable to conclude that Mandarin-learning children have basic sensitivity to the presence/absence contrast of the two verb classes in the inversion construction. They not only are sensitive to the word order in their mother tongue (e.g., head direction), but are also aware of certain linguistic contrast related to word order.

This study offers preliminary evidence for children's sensitivity to the presence/absence of unaccusative and unergative verbs in the inversion construction. They treated the absence of unergative verbs in the inversion construction in the input as an indication that these verbs were not the same as the unaccusative verbs. A similar effect has been observed in a recent study (Koulaguina & Shi, 2019), which trained 14-month-old infants with an artificial grammar involving some sentences exhibiting a systematic word order shift and others without any shift. Their experiments showed that infants treated the non-shifting sentences as distinct from those that shifted the word order. Thus, the results of that study and of the present study suggest that the absence of a word order inversion for specific exemplars can be a useful cue for the child to potentially discover distinct structures associated with different exemplars.

A question that immediately follows is what children extract from this contrast in the input. To begin with, by tracking verb use in the input, children can roughly divide intransitive verbs into two groups in terms of whether a verb occurs in the inversion construction. In other words, they can obtain distributional information from the contrast between unaccusative and unergative verbs in inversion constructions, which can later become part of their knowledge on specific verb items.

Hence, distributional cues might act as the starting point towards full mastery of unaccusativity. Considering the underlying semantic contrast between the two verb classes, it is also possible that children would inductively form semantic classes of different verbs based on distribution (Yang, 2016). Previous studies have found that preschool children are sensitive to certain semantic features underlying the unaccusative-unergative distinction in their native language. For example, Lu (2019) shows that preschoolers are sensitive to semantic features that distinguish unaccusative verbs from unergative verbs in Mandarin. Randall et al. (2004) found that Dutch-speaking and German-speaking children categorize novel intransitive verbs into two classes (reflected in auxiliary selection) based on semantic features such as telicity. If children are sensitive to verb semantics at an early stage, they might be able to combine the semantic cue and distributional cue to get the whole picture of unaccusativity. Abstract knowledge of verb argument structure, for example, could be formed using input information and certain linking rules that map participants in different types of events to their corresponding argument positions (Levin & Rappaport Hovav, 1995). Using familiar verbs in experiments, this study shows that children are sensitive to the distribution contrast (presence vs. absence) of the two verb classes in the inversion construction. It does not offer evidence, though, on how children come to distinguish the two verb classes: whether using distributional information or verb semantics, or both. Further experimental studies with novel verbs could test different cues separately to see how each of them functions during verb learning.

There is no doubt that input properties in the ambient language have an important role in verb learning, but there is no consensus yet as to how and when children benefit from them and in what way they interact with abstract representations that may already have been acquired to learn the structure and meanings associated with particular verbs or verb classes. The current experimental study discusses whether one type of distributional cue, i.e., the presence/absence contrast in the inversion construction, possibly guides children in differentiating unaccusative and unergative verbs. The upshot of our results is that 19-month-old Mandarin-learning toddlers are sensitive to the presence/absence contrast of unaccusative and unergative verbs in the inversion construction. Despite the lack of overt morphological cues, Mandarin-speaking children's sensitivity to the distributional difference between the two verb classes emerges before age two. As a first step in investigating how children acquire the unaccusative-unergative distinction, this study lays ground for further investigations on the role of language-specific input cues, which would shed light on the acquisition of complex semantic-syntactic interface knowledge in general.

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