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Language and age effects in children's processing of word order

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ABSTRACT

We compare the processing of transitive sentences in young learners of a strict word order language (English) and two languages that allow noun omissions and many variant word orders: Turkish, a case-marked language, and Mandarin Chinese, a non case-marked language. Children aged 1–3 years listened to simple transitive sentences in the typical word order of their language, paired with two visual scenes, only one of which matched the sentence. Multiple measures of comprehension (percent of looking to match, latency to look to match, number of switches of attention) revealed a general pattern of early sensitivity to word order, coupled with language and age effects in children's processing efficiency. In particular, English learners showed temporally speedier processing of transitive sentences than Turkish learners, who also displayed more uncertainty about the matching scene. Mandarin learners behaved like Turkish learners in showing slower processing of sentences, and all language groups displayed faster processing by older than younger children. These results demonstrate that sentence processing is sensitive to crosslinguistic features beginning early in language development.

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Every language includes way(s) to show relational information about the participants of an action (O'Grady, 2005). Languages may employ three grammatical devices to denote relations between agents (doers of an action) and patients (undergoers of an action): case markers, word order, and verb agreement (Comrie, 1981; Greenberg, 1963). While no language relies on any of these devices exclusively, some languages (e.g., English) rely more heavily on word order whereas other languages (e.g., Turkish) rely more heavily on case markers. In addition, some languages exhibit word order variations without a transparent case-marking system; these languages (e.g., Mandarin) rely more on other cues such as animacy contrast and discourse pragmatics to identify agent–patient relations. Furthermore, languages such as Turkish and Mandarin exhibit frequent omission of nouns.

These crosslinguistic differences notwithstanding, children and adults speaking all three types of languages have shown tendencies to use word order as a significant cue for sentence comprehension (Chang & Tseng, 1988; Göksun, Küntay, & Naigles, 2008; Hirsh-Pasek & Golinkoff, 1996). Furthermore, word order seems to emerge as a useful aid to sentence comprehension, even by adult speakers of languages for whom it is not the most reliable cue (Demiral, Schlesewsky, & Bornkessel-Schlesewsky, 2008, for Turkish). The question we address here is *how* this word order processing is carried out at the very beginning of language use. That is, are there age-related or language-related differences in the patterns of processing by which 1-3-year-olds begin to use word order to understand transitive sentences? We compare children learning Turkish and English in Experiment 1 and add (with a slightly modified design) children learning Mandarin in Experiment 2.

Turkish has a rich inflectional system, such that relations between participants can be identified by endings on nouns. For example, to express the sentence "John loves Mary" in Turkish, one can say:

(1) *Can Meri-***yi** *seviyor* (in canonical SOV [Subject–Object–Verb] order).

The accusative case marker "*(y)i*" identifies the direct object (Meri, in this case). With it, one can also say "*Meri-yi Can Seviyor*" (OSV order) or "*Can seviyor Meri-yi*" (SVO order). Turkish word order is relatively flexible although the most typical order is SOV (Erguvanlı, 1984), and nouns in both subject and object positions can be omitted. Moreover, it is possible to omit the accusative case marker on the patient noun phrase (NP) under some circumstances—notably when the NP is located before the verb (as in SOV word orders) and its meaning is either generic or indefinite (Dede, 1986; Erguvanlı-Taylan & Zimmer, 1994; von Heusinger & Kornfilt, 2005). Indeed, 4-year-olds omit accusative marking for the object NP to indicate that the referent of the object NP is newly introduced into discourse, and therefore is indefinite (Küntay, 2002).

The other end of the continuum from Turkish includes languages that are inflected very little, such as English, and that have no morphological cues, such as Mandarin Chinese. The word orders of these languages play a more important and consistent role in encoding relational information. For example, the canonical word order in English is SVO (2). The same words can be combined in different ways to form another well-formed sentence, as seen in (3), but convey semantically different propositions.

(2) *John likes Mary*.
(3) *Mary likes John*.

While Mandarin word order is also canonically SVO, it allows other word orders in many situations (Li & Thompson, 1981) as well as omitted nouns, both of which we will discuss.

These typological features of Turkish and English carry over to child-directed speech. Studies of Turkish child-directed speech find varied word orders common. In Turkish child-directed utterances containing two nouns and a verb, Slobin and Bever (1982) found five different word orders (SOV, SVO, OVS, OSV, and VSO) with the least frequent (VSO) still accounting for 6% of the data. Moreover, when consecutive utterances share the same communicative intention—so-called variation sets (Küntay & Slobin, 1999)—the verbs often change position (Küntay & Slobin, 1996, 2001). However, despite real variation, the SOV order is clearly the most dominant, accounting for 48% of the Slobin and Bever (1982) data. On the other hand, subject omission is also frequent, reported in 70% of transitive clauses in adult conversations (Demiral et al., 2008); moreover, of sentences beginning with an NP in the METU-Sabancı Treebank adult corpus (Oflazer, Say, Hakkani-Tür, & Tür, 2003), subject-initial (52%) and object-initial (48%) sentences appear approximately equally often. Thus, although the SOV order predominates in Turkish, whether the first NP is subject or object could at times be indeterminate.

In contrast to Turkish, examinations of child-directed speech in English have revealed that first NPs strongly tend to be used in the grammatical role of subject in actional transitive (i.e., 2-NP) utterances. Moreover, noun omission is rare, so that most transitive utterances include overt subjects and objects in the canonical SVO order (Chan, Lieven, & Tomasello, 2009; Naigles & Hoff-Ginsberg, 1995).

The most common method to compare processes of sentence comprehension across ages and languages has been to ask participants to interpret sentences whose cues to agent–patient relations are manipulated. Slobin and Bever (1982), Bates and MacWhinney (1987), Bates et al. (1984) and MacWhinney, Pleh, and Bates (1985) were pioneers in this approach, comparing children's ability to interpret 2-NP sentences of different word orders (e.g., NVN vs. NNV), with vs. without case markers, and whose nouns varied in animacy, stress, and so on. Even at early ages, consistent preferences for different grammatical cues have been observed in children learning different languages. For example, English learners rely predominantly on SVO word order at 1–2 years of age (Bates et al., 1984; Chan et al., 2009; Gertner, Fisher, & Eisengart, 2006; Hirsh-Pasek & Golinkoff, 1996; Slobin & Bever, 1982), while young learners of case-marked languages (e.g., Hungarian, Japanese, Korean, Turkish) have been shown to rely on both case markers and word order to interpret 2-NP sentences, starting at 2–3 years of age (Göksun et al., 2008; Hakuta, 1982; MacWhinney et al., 1985; No, 2009).

It is noteworthy that canonical word order emerges as an exploited cue to sentence comprehension, certainly by 3 years of age, even in children learning languages whose linguistic organization makes little use of word order. Thus, here we study early sentence comprehension a bit differently from previous researchers. Rather than investigating how different cues are acquired and weighted across languages, we take one cue, word order, and investigate how children's use of this cue, in terms of their real-time sentence processing, may differ by age and language. We employ the intermodal preferential looking paradigm (IPL), in which children's eye movements are coded while they are actually listening to a test sentence and being asked to choose between two side-by-side scenes as the referent of that sentence. This method has been successfully and predominantly used to investigate children's processes in the domain of word recognition. For example, English-speaking toddlers' latency to look at a matching object (i.e., when told to 'find the ball' while both a ball and a sock are shown) decreases 400 ms between 18 and 30 months of age (Lew-Williams & Fernald, 2007); they become more efficient in processing familiar words as they develop. Similar decreases in processing time with age have been found in Spanish-speaking preschoolers' word recognition (Hurtado, Marchman, & Fernald, 2008; Piotroski & Naigles, 2012; Swingley, 2012).

IPL has been used to investigate sentence (as well as word) comprehension in 1–3 year olds; however, most studies report only variants of a trial-wide 'amount of looking to the match' measure (Chan, Meints, Lieven, & Tomasello, 2010; Naigles, 1990; Naigles, Bavin, & Smith, 2005; Wagner, Swensen, & Naigles, 2009), and hence provide an offline measure of processing. Two recent studies, however, have reported some potentially interesting timecourse-of-processing effects. Gertner et al. (2006) found that 21-month-old English learners, tested on SVO sentences with novel verbs, showed significant preferences for the match during the first 2 s of an 8-s trial. In a partial replication with German learners, Dittmar et al.'s (2008) 21-month-olds showed significant preferences for the matching scene only during the latter half of the trial. Given that English is a word-order language and German a case-marked language, one interpretation of these findings is that English learners process word order more quickly than German learners, most probably because word order is not as dominant a cue in German as in English. In the present study, we test 1-, 2-, and 3-year old English, Turkish, and Mandarin learners with only their language-specific canonical word order (SVO for English and Mandarin, SOV for Turkish), to compare how efficiently these forms are processed across languages and across ages. Because no cross-language comparisons are free from cross-setting differences in implementation, we also assess the extent to which the differences found could be attributed to differences other than language itself.

We propose to measure children's timecourse of sentence comprehension with three classes of dependent variables. The first class involves the percent (of total looking time) of time children spend looking at the video designated as the 'match' during test trials, compared with their looking at the same video during control trials (when no directing audio is given). This measure provides an indication of the extent to which children shifted their attention to the video matching to the meaning of the sentence that they heard in the test audio, thus providing evidence that the test audio changed

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children's video preference in the correct direction. We also assess percent of looking time to the match separately during the 1st (after the first presentation of the test audio) and 2nd (after hearing the test audio a 2nd time) half of each test trial. Matching only during the 2nd half might be indicative of a slower processing speed and/or less facility with word order as a cue to sentence comprehension.

A second measure assesses efficiency more directly. Once audios and videos are presented, how long does it take children to find the matching scene (Fernald, Zangl, Portillo, & Marchman, 2008)? This latency to \ matching scene is compared for control (nondirecting audio) and test (directing audio) trials. During the control trials the relative speed of the child's first look to the match is likely based on stimulus salience, which is probably acted on speedily. In contrast, during the test trials first look to the match must be based on processing of the test sentence, which likely takes additional time. The control–test comparison, then, measures the amount of additional time that processing the sentence takes. Measuring latency to the match during the test trial itself can also reveal age and language effects on speed of sentence processing. The final measure is the number of switches of attention children make on control vs. test trials. This measure may assess something about children's continuing certainty about the match between audio and video. Children should switch attention more during control trials, when there is no directing audio to guide looking, than during test trials, when attention should be more focused on the matching video if the test audio is understood. To our knowledge, this measure has never before been used to investigate on-line language processing of 1–3-year-olds.

In sum, given young children learning many different languages demonstrate significant use of word order as a cue to sentence comprehension, we investigate the timecourse of the use of this cue in children from three different age groups, 1-, 2-, and 3-years of age, learning three very different types of languages, English, Turkish, and Mandarin. Because we hope to tap the very beginnings of word order use, we present the children with 2-NP sentences containing familiar verbs, acted out by people dressed in bird and horse costumes. Because we are using the sensitive IPL methodology, where children need only sit in a chair and look at two side-by-side scenes for 4–6 min, we expect to find evidence of word order comprehension as early as other IPL studies and possibly earlier than the extant studies using act-out or pointing tasks (Chan et al., 2010; Fisher, 2002; Göksun et al., 2008; Naigles, 2002). Our more specific predictions are as follows: (1) Children whose language's canonical word order is a more reliable cue to agent–patient relations should show significant match preferences early in the test trial, whereas children whose language's canonical word order is a less reliable cue should only show such preferences later in the test trial. (2) Younger children, who are at earlier stages of mastery of their language's canonical word order, may display match preferences only during the latter intervals of the test trial. (3) Children whose language's canonical word order is a more reliable cue to agent–patient relations should show faster latencies to the match than children whose language's canonical word order is a less reliable cue to agent–patient relations. (4) Older children, as overall better language processors, should show faster latencies to the matching scene than younger children. (5) Children whose language's canonical word order is a more reliable cue to agent–patient relations should display fewer shifts of attention during the test trials than children whose language's canonical word order is a less reliable cue to agent–patient relations; the former children should be more certain that they have found the correct/matching scene. (6) Older children should be more certain of the matching scene than younger children and therefore should display fewer shifts of attention during the test trials.

1. Experiment 1

1.1. Method

1.1.1. Participants

A total of 184 children in the US and Turkey participated. Table 1 presents sample sizes by age and language group and scores on standardized language tests. Genders were roughly equivalent within groups. Participants in the US were secured via birth announcements in local newspapers. Turkish participants were recruited through announcements on parenting websites and by contacting organizations that provide early childcare and entertainment. Participants in both locations were

Table 1
Demographic and standardized test information by age and language group (means and standard deviations).

Age group and score	Language group	
	Turkish	English
3-year-olds		
N	44	22
Mean age (range)	37.23 (33.30–39.93)	36.59 (34.99–38.17)
Mullen Scales (raw)		
Expressive language	34.82 (5.41)	37.82 (2.48)
Receptive language	32.93 (2.77)	35.11 (1.62)
Visual reception	36.6 (3.30)	40.64 (2.95)
Fine motor	32.60 (4.59)	33.71 (1.92)
MacArthur CDI	–	614.29 (80.09)
2-year-olds		
N	41	32
Mean age (range)	27.53 (25.3–29.56)	27.76 (26.4–28.99)
Mullen Scales (raw)		
Expressive language	27.02 (5.48)	28.72 (8.77)
Receptive language	28.15 (2.91)	29.25 (7.03)
Visual reception	31.44 (3.49)	31.69 (2.94)
Fine motor	26.3 (2.24)	27.4 (2.41)
MacArthur CDI	–	387.52 (194.78)
1-year-olds		
N	24	21
Mean age (range)	18.16 (17–19.96)	18.87 (17.67–19.99)
Mullen Scales (raw)		
Expressive language	16.33 (3.46)	18.9 (2.97)
Receptive language	19.33 (4.00)	23.57 (7.75)
Visual reception	22.00 (3.73)	22.52 (2.52)
Fine motor	19.80 (2.98)	21.2 (1.89)
MacArthur CDI	–	94.6 (77.87)

monolingual learners of their respective languages and were from middle- or upper-middle class families. The two language groups were comparable in their language skill levels, as their performance did not differ significantly for any of the subscales of expressive language, receptive language, visual reception, and fine motor skills (*ps* > .50) obtained by the Mullen Scales of Early Learning (Mullen, 1995).

An additional 50 children (10 American and 40 Turkish children) were excluded based on these criteria: side preferences (more than 80% to one side; 6 American and 9 Turkish participants); inattention and/or lack of cooperation (18 Turkish participants), experimenter error (4 American and 9 Turkish participants), and low scores on the developmental assessment (total scores more than 2 standard deviations below the mean, 4 Turkish participants). These proportions of exclusion are within the range previously reported for the IPL task (Brandone, Pence, Golinkoff, & Hirsh-Pasek, 2007; Naigles et al., 2005; Wagner et al., 2009). We conjecture that more Turkish children showed high levels of inattention because parental control, which is usually more frequent in Turkish than in comparable American samples (Akcinar & Baydar, 2011), was reduced in the unfamiliar lab environment; moreover, more experimenter errors may have been committed in Turkey at the beginning of the study because of the novelty of the IPL paradigm for the Turkish researchers. Mullen scores (see below) for excluded children were not significantly lower than for the included children in either language group.

1.1.2. Stimuli

Audio stimuli. The nouns used in the transitive sentences were *at*/horse and *kuş*/bird. To ensure comparability to English and to isolate word order as a potential cue, the Turkish nouns were produced without case-marking. The test sentences consisted of simple transitives such as *At kuş it-iyor/The horse is pushing the bird*. The Turkish sentences included four verbs: *it* 'push', *çek* 'pull', *yıka*, 'wash', and *gıdıkla* 'tickle'. The English sentences included these four verbs in the same order given to Turkish participants plus two additional ones: *hug* and *ride* (which were included to enable overlap with the Mandarin verbs used in Experiment 2). Two versions of the test sentence were created for each verb. For one, the first noun referred to the horse; for the other, the first noun referred to the bird. All sentences were constructed in the canonical word order of the relevant language, thus, in SOV in Turkish and SVO in English. The sentences were recorded by an adult female native speaker using child-directed prosody.

Video stimuli. Two adults dressed in costumes of a bird and a horse were filmed performing the actions depicted by the above verbs. There were two video clips for each of the reversible events, one with the horse as the actor and the bird as the undergoer (e.g., the horse pushes the bird), and the other with the roles reversed (e.g., the bird pushes the horse). In addition, the costumed characters were filmed while waving their right hand at the camera; these clips were used in the introductory character identification trials.

1.1.3. Procedure

There were 8 trials for each verb/action block. Trials 1 and 2 were familiarization trials, when each reversible action was introduced sequentially, along with the verb in isolation (thus not mentioning either of the characters: e.g., *İtiyor*/'Pushing'). Trial 3 was the control trial, in which both videos were presented simultaneously along with a non-directing audio (e.g., *Bak iki tarafta da var*/'They are on both screens'); this trial provided the indication of the relative salience of the two videos. Trial 4 was the test trial, in which both videos were presented simultaneously again, while the audio now directed the participants to look at one of the videos (e.g., *At kuş it-iyor*/'The horse is pushing the bird'). The duration of each of these trials was 6 s; three-second 'blanks' preceded each trial (the intertrial intervals), when the audio was presented without the video.

The audio stimuli were counterbalanced within participants such that half of the test sentences included the horse as the subject and half included the bird as the subject. In addition, the side of the screen carrying the matching video was alternated across trials. Across participants, the sides for the videos were varied (for some participants, the horse was consistently on the left and for others, consistently on the right); moreover, each video was shown with both possible test audios across participants (i.e., some participants heard the test audio "the horse is washing the bird" while others heard "the bird is washing the horse").

1.1.4. Apparatus

In Turkey, the video stimuli were projected from a laptop onto a 163 cm × 120 cm white screen via an LCD projector. The audio stimuli were diverted from the laptop to a speaker centered below the screen. A blinking red light centered between the event videos attracted children's attention to the center between trials. Children were seated on a toddler-size chair approximately 1 m from the screen. A digital camera located in front of the screen recorded children's eye movements. In the U.S., the video stimuli were displayed on two video monitors placed 12 in. apart on a table. A speaker hidden between and behind the two monitors played the audio stimuli. Mounted between the monitors was a rope of red chase-lights used to attract the child's attention to the center between trials. Children were seated in a booster seat two feet away from the monitors. Their faces were filmed by a digital camera hidden behind the light.

In both locations, parents usually sat on a chair behind their children. In some cases, children were tested while sitting on their parents' laps to ensure cooperation. Parents were instructed to close their eyes and not guide their children toward any of the videos. After the viewing session, the experimenter administered the Mullen Scales of Early Learning (Mullen, 1995). American parents filled out the Toddler version of the Macarthur-Bates Communicative Development Inventory (CDI; Fenson et al., 1994).

1.1.5. Coding of dependent variables

The child's visual fixations were coded frame by frame from silent video. An individual trial was considered missing if the child looked at both scenes, combined, for less than 0.6 s. In the American group, 2–3% of trials were missing in each age group. In the Turkish group, 4.58% and 4.25% of trials were missing for the 1-year-old and the 2-year-old groups respectively and 1.7% of trials were missing

Table 2
Percent looking time to match during control and test trials by age and language group (Experiments 1 and 2).

	English			Turkish			Mandarin		
	Age 1	Age 2	Age 3	Age 1	Age 2	Age 3	Age 1	Age 2	Age 3
Control									
Mean	.460	.513	.500	.518	.476	.489	.528	.490	.481
SD	.138	.084	.114	.114	.133	.097	.065	.101	.083
Test: 1st half									
Mean	.543	.539	.548	.530	.547	.514	–	.493	.542
SD	.129	.149	.113	.153	.163	.167	–	.158	.164
Test: 2nd half									
Mean	.502	.445	.599	.515	.543	.556	–	.512	.530
SD	.220	.141	.128	.160	.179	.184	–	.151	.163
Test: total									
Mean	.517	.484	.579	.545	.531	.536	.522	.493	.541
SD	.142	.137	.097	.106	.126	.141	.079	.101	.124

for the 3-year-old group. These missing trials were replaced by the mean for the given item in the given age group.

Interrater reliability of the coding was assessed at an American IPL lab not involved in the data collection. The (silent) video files 10% of each age and language group were coded by individuals unfamiliar with the study. Correlations between the original and reliability coders averaged .95 for the American and .98 for the Turkish group.

Five dependent variables were calculated: (a) percent of time the child looked at the video designated as the 'match' of the total looking time to one of the videos, (b) percent of looking time to the match during the 1st half of each test trial, (c) percent of looking time to the match during the 2nd half of each test trial, (d) latency to the match for control and test trials, and (e) number of switches of attention for control and test trials.

1.2. Results and discussion

We conducted three-way analyses of variance (ANOVAs) for each dependent variable, with age and language group as between-subjects measures; the within-subject measure was performance on each variable during control vs. test trials. Preliminary analyses showed no effects of gender; thus genders were combined in all analyses. All analyses were in addition conducted using only data regarding the four common verbs across Turkish and English; the results revealed no subtantial differences from those reported below.

1.2.1. Percent looking to match

As Table 2 shows, children overall looked longer at the matching screen during the entirety of the test trials than during the control trials. (Experiment 2 results for the Mandarin sample are included for later comparison.) A 3-way ANOVA revealed only a significant main effect of trial type [$F(1,178) = 17.11$, $p < .001$, $\eta_p^2 = .088$]. A similar main effect of trial type was found for first half of the test trial [$F(1,178) = 12.739$, $p < .001$, $\eta_p^2 = .067$]; therefore, even early in the trial, across language and age groups children generally looked longer at the matching video. In contrast, for looking only during the second half of the test trial, main effects of trial type and age were found [trial: $F(1,178) = 6.539$, $p = .011$, $\eta_p^2 = .035$; age: $F(2,178) = 3.223$, $p = .042$, $\eta_p^2 = .035$], qualified by a 3-way interaction of age, language and trial type [$F(2,178) = 3.26$, $p = .041$, $\eta_p^2 = .035$]. Two-way ANOVAs for each age group (language × trial type) and language group (age × trial type) were thus conducted.

For the 1-year-old group, the ANOVA yielded no significant effects or interactions for the 2nd half of the trial. Thus, 1-year-olds seem to lose interest and/or are unable to maintain their matching preference during the 2nd half of the trial. The ANOVA for the 2-year-old group yielded a significant trial type X language interaction [$F(1,71) = 5.746$, $p = .019$, $\eta_p^2 = .075$]. The 2-year-old English learners also

Table 3
Latency to match during control and test trials by age and language group (Experiments 1 and 2).

	English			Turkish			Mandarin		
	Age 1	Age 2	Age 3	Age 1	Age 2	Age 3	Age 1	Age 2	Age 3
Control									
Mean	1.864	1.447	1.424	1.866	1.496	1.474	1.803	1.729	1.364
SD	.946	.784	.718	1.028	.936	.911	.793	.902	.568
Test									
Mean	2.269	1.801	1.537	1.716	1.766	1.722	2.049	2.179	1.595
SD	.665	1.286	.739	.846	.931	.822	.720	.920	.803

Table 4
Number of switches during control and test trials by age and language group (Experiments 1 and 2).

	English			Turkish			Mandarin		
	Age 1	Age 2	Age 3	Age 1	Age 2	Age 3	Age 1	Age 2	Age 3
Control									
Mean	6.24	7.04	7.42	8.12	7.86	8.42	6.70	7.05	7.59
SD	.70	1.27	1.06	2.30	1.52	1.73	1.93	1.24	1.24
Test									
Mean	5.77	6.08	6.99	7.22	7.20	7.26	6.14	6.26	6.94
SD	.89	1.06	.84	1.77	1.56	1.40	1.75	1.44	1.43

looked less at the matching screen during the 2nd half of the test trial; in contrast, 2-year-old Turkish learners show an *increased* preference for the match during the 2nd half. The ANOVA for the 3-year-old group yielded only a significant effect of trial [$F(1,64) = 14.272$, $p < .001$, $\eta_p^2 = .18$]. Similar patterns are observed within each language. An ANOVA for the English learners yielded only a significant interaction of trial and age [$F(1,72) = 4.433$, $p = .015$, $\eta_p^2 = .11$], with 3-year-olds showing stronger matching preferences during the 2nd half of the trial than 1- and 2-year-olds, whereas for the Turkish learners the ANOVA yielded only a main effect of trial type [$F(1,106) = 4.772$, $p = .03$, $\eta_p^2 = .04$]. Degree of comprehension (captured by the difference between test and control scores) was not correlated with Mullen subscores in either language group.

1.2.2. Latency

Table 3 shows that children overall took longer to look to the matching screen during the test trials than during the control trials, confirmed in a 3-way ANOVA by a significant main effect of trial [$F(1,178) = 4.239$, $p = 041$, $\eta_p^2 = .023$]. (Experiment 2 results for the Mandarin sample are included for later comparison.) A main effect of age was also found [$F(2,178) = 4.549$, $p = .012$, $\eta_p^2 = .049$], with post hoc Scheffe tests revealing that 1- and 3-year-olds differed in overall latencies ($p = .019$; the 3-year-olds had shorter latencies overall), and the 2- and 3-year-olds differing marginally ($p = .093$). No significant differences appeared across language groups.

1.2.3. Switches

As shown in Table 4 (again including Experiment 2 results), children across language and age groups switched attention more during control trials than during test trials, and Turkish children switched attention more overall than American children. An ANOVA revealed significant main effects of trial [$F(1,178) = 50.063$, $p < .001$, $\eta_p^2 = .220$], age [$F(2,178) = 4.048$, $p = .019$, $\eta_p^2 = .044$], and language [$F(1,178) = 30.189$, $p < .001$, $\eta_p^2 = .145$], but no significant interactions. Post hoc Scheffe tests revealed that 3-year-olds switched overall more frequently than the 1-year-olds ($p = .014$) and marginally more frequently than the 2-year-olds ($p = .057$); moreover, Turkish learners switched more frequently than English learners in both control [$F(1,182) = 26.66$, $p < 001$, $\eta_p^2 = .128$] and test trials [$F(1,182) = 21.27$, $p < .001$, $\eta_p^2 = .105$].

1.2.4. Discussion

These findings indicate that canonical word order is available to both English and Turkish learners early in development as a cue to sentence interpretation. Such findings are not a surprise for the English sample and corroborate those reported by Hirsh-Pasek and Golinkoff (1996; see also Gertner et al., 2006). However, the findings are new and surprising for the Turkish sample, as they demonstrate a sensitivity to SOV word order (Batman-Ratyosyan & Stromwold, 2002) in children as young as 27 months of age (at least, those from upper-middle SES families), learning a language whose overall propensity is to signal grammatical relations with case markers and whose child-directed speech contains many utterances that are not in SOV order and that involve noun omissions. It is possible that word order reliance was found in Turkish only because case marker information was not available. Some Turkish children might have slowed down in the processing of our NNV sentences with no case markers because they searched for the case marker. Slobin and Bever (1982) showed that Turkish children responded less consistently to sentences without inflections. Further investigations may include case markers and vary word orders to see how these cues interact.

Timecourse analyses revealed both language-relevant and age-specific patterns. In the first part of the trial, the general pattern across age and language groups (save, perhaps, the Turkish 1-year-olds; see Table 2) was to match the audio stimulus to the associated video significantly more in the test as opposed to the control trial. In the second part of the trial, however, the matching performance showed age-dependent and language-dependent patterns. One-year-olds overall showed little preference for looking to the matching video in the second part of the test trial; English-learning 2-year-olds were similar. However, Turkish 2-year-olds increased their preference for the match during the second half of the trial, and 3-year-olds in both language groups maintained their match in the second half of the trial. For the latency measures, the test trials overall elicited slower turns to the video matching the auditory stimulus, compared to control trials. Moreover, the two older groups located the match more quickly than 1-year-olds. Finally, whereas both language groups shifted attention more frequently during the control than test trials, Turkish children shifted attention more frequently than American children.

Could language group effects have been attributable to differences in the IPL setups in the two locations? One difference between the setups concerned audio timing. Although children in both countries heard the test audio fully before the test trials began, the test audios presented during the test trials were not standardized for the timing of when the 1st NP was produced. Post hoc analyses of the onset times of the 1st NP showed that the mean 1st NP onset time was slightly earlier for Turkish than English—1.28 s ($SD = .059$) vs. 1.52 s ($SD = .382$). Thus, the timing of the 1st NP cannot account for language differences in latency nor the 1st vs. 2nd half differences.

A second difference between the setups was that the English-learning children watched more verbs (6 vs. 4 in Turkish), affording them more opportunity to improve. As noted earlier, the qualitative results remain the same if only the first four English verbs (which were identical to the Turkish verbs) are considered. Moreover, there is little evidence that children improved across trials in this task. Although the English learning 2-year-olds did improve from the 2nd verb (*tickle*, 52% shifted to the match) to the 6th verb (*ride*, 65% shifted to the match), no similar improvements were found for Turkish 2-year-olds—64% shifted to the match for *push* (1st verb) and 65% shift to the match for *pull* (3rd verb), nor for the 1-year-old English learners—67% shifted to the match for *push* (1st verb), 67% did so for for *pull* (3rd verb) and 62% did so for *ride* (6th verb).

A final difference concerns physical differences between the set-ups, such as whether one large screen or two small screens were used. These differences have not led to performance differences in other studies (Wagner et al., 2009) and also do not seem to have affected attention levels in this study. An examination of looks away from the screens showed that older children looked away less often [$F(2, 178) = 8.10$, $p < .0001$, $\eta_p^2 = .084$] but no differences across languages were found (see Table 5).

Overall, these findings support surprisingly early and efficient processing of sentences in SOV order but lacking case markers, by Turkish 2–3 year olds, and of SVO sentences by English-learners of comparable age and SES. Language group effects do not seem attributable to differences in the IPL setups, nor to differences in language or SES levels. However, Turkish morphosyntax differs from that of English in a number of ways, including the (usual) presence of case markers, the (canonical) word order of SOV, and the allowance of noun omissions. Thus, it is not clear which of these components—or a

Table 5
Percentage of looking away during control and test trials by age and language group (Experiment 1).

	English			Turkish		
	Age 1	Age 2	Age 3	Age 1	Age 2	Age 3
Control						
Mean	30.17	19.46	18.20	25.32	21.85	19.02
SD	16.58	12.47	7.98	18.52	14.83	15.95
Test						
Mean	29.08	19.56	17.53	29.48	27.22	18.16
SD	17.79	13.53	9.23	18.49	17.09	10.28

combination—might be contributing to the language differences obtained in Experiment 1. In Experiment 2 we thus investigated word order comprehension in a language that also allows noun omissions but has a canonical word order of SVO and includes no case markers, Mandarin Chinese.

2. Experiment 2

Canonically, Mandarin has SVO order, as shown in (4) below.

(4)	*wo3*	*xi3huan1*	*gou3*
	I	like	dog
	I like dogs.		

However, Mandarin learners face a more complex situation than do English learners because Mandarin allows word order variation. For example, the use of *ba3* (to get) yields SOV order as shown in (5):

(5)	*wo3*	*ba3*	*wan3*	*xi3*	*le*	(SOV because of ba3)
	I	BA	dish	wash	Perfective	
	I got the dishes washed (completed action).					

Moreover, omissions of nouns can yield SV or OV orders, as shown in (6) and (7):

(6)	*wo3*	*xi3*	*le*	(SV)
	I	wash	Perfective	
	I washed (them)			

(7)	*ba3*	*wan3*	*xi3*	*le*	(OV)
	BA	dish	wash	Perfective	
	(I) washed the dishes				

Other devices such as the definite/indefinite contrast and topicalization result in additional word order variants (Li & Thompson, 1981). Lee and Naigles' (2005) analysis of the Beijing corpus on CHILDES (MacWhinney, 2000) revealed that while SVO was the most frequent order, and *ba3* was not used frequently, although it has been well-attested in the adult language (Cheung, 1992), nonetheless direct object omissions occurred in up to 60% of the transitive utterances parsed. More detailed analyses (Huang & Chui, 1997) have corroborated that Mandarin learners in Taiwan hear more NV utterances (40% of total) than NVN utterances (20% of total), and that of all NV utterances, both SV and OV are well-attested orders.

Perhaps not surprisingly, children age 3 and older act out SVO utterances on the basis of word order rather than semantic plausibility (Chang & Tseng, 1988; Miao, Chen, & Yin, 1984). Chan et al. (2009) have shown that 3.5-year-olds learning Cantonese were able to act out reversible SVO sentences with novel verbs whereas 2.5-year-olds performed at chance. Lee and Naigles (2008) demonstrated that 2- and 3-year-old Mandarin learners interpreted NVN sentences with intransitive verbs as following SVO order. Experiment 2 is the first IPL investigation of sentence processing in child Mandarin learners; therefore, it seemed reasonable to use the canonical SVO frame.

We showed Mandarin-speaking 1–3-year-olds many of the same video clips seen by the Turkish and American English learners in Experiment 1. Age-related predictions for each dependent variable are identical to those of Experiment 1. For language-related predictions, it is possible that Mandarin learners will behave more like English learners, because their canonical word orders are both SVO and neither language has case marking, and because the current sentence comprehension task provides no discourse information. However, it is also possible that they will behave more like Turkish learners, because both languages allow both SV and OV utterances, making word order less informative as a cue to agent–patient relations in sentences where two nouns occur with a single verb and there are no contextual or prosodic cues to determine agent–patient relations.

2.1. Method

2.1.1. Participants

Fifty-two children aged 17–36 months participated. They comprised three age groups: 16 18-month-olds ($M = 18.4$ months, $SD = 4.26$, 8 boys), 18 24-month-olds ($M = 24.6$ months, $SD = 1.25$, 10 boys), and 18 34-month-olds ($M = 33.8$ months, $SD = 0.99$, 8 boys). Children were recruited through announcements on parenting websites. An additional 11 children were eliminated from the final sample because of inattention/lack of cooperation (9) or experimenter error (2).

All participants were native monolingual learners of Mandarin Chinese. Their production vocabulary was measured by using the Chinese version of the CDI (Tardif, Fletcher, Zhang, Liang, & Zuo, 2008). The production vocabulary of the 18-month-olds ranged from 1 to 385 words ($M = 171.56$, $SD = 138.87$), that of the 24-month-olds from 66 to 691 words ($M = 328.11$, $SD = 196.73$), and that of the 34-month-olds from 108 to 776 words ($M = 614.07$, $SD = 159.75$). These mean scores are somewhat lower than those reported for these ages by Tardif, Fletcher, Liang, and Kaciroti (2009); namely, around 200 words for 18-month-olds, in the mid-500 words for 24-month-olds, and around 700 words for 30-month-olds, suggesting that children in our sample were not as advanced in language development as is typical for their age. However, Tardif et al.'s sample comes from a different population of Mandarin speakers (living in Beijing rather than Taipei); moreover, Tardif et al.'s procedure included longer and more prompt-filled interviews with caregivers than ours. Thus the vocabulary scores reported here may be underestimates.

2.1.2. Stimuli and design

The stimulus displays included actions performed by the same people in horse and bird costumes as in Experiment 1, and the videos were created according to the same pattern: a series of 6-s video events and 3-s inter-trial intervals. The Mandarin stimuli differed from those used in Experiment 1 in two ways. First, the test phase included six high-frequency Mandarin verbs selected from work by Lee and Naigles (2005): '*qi2*' (ride), '*tui1*' (push), '*qin1*' (kiss), '*la1*' (pull), '*ca1*' (wipe) and '*bao4*' (hug). Five of these overlapped with those used in English or Turkish, but '*qin1*' (kiss) was unique to Mandarin. Second, during control trials the audio simply presented the verb again without any nouns (*Hei4! Tui zher!*/"Hey, pushing"), instead of highlighting that the videos were now appearing on both screens. The Mandarin version is more similar to Hirsh-Pasek and Golinkoff's (1996) original word order study.

2.1.3. Apparatus and procedure

The apparatus and procedure were very similar to those used in Experiment 1. The parent first spent approximately 20 min filling out the MacArthur CDI and then the experimenter escorted parent and child to the testing room. The child sat on the parent's lap and both faced the screen. The parent was told not to direct the child to either video.

2.1.4. Coding and dependent variables

Coding was identical to that used in Experiment 1. However, because of some data loss within the 1-year-old group, only the percent looking to the match measure during the entirety of the control and test trials was available for all participants. The other four variables were thus only analyzed for the 2-year-old and 3-year-old groups. The video of each child was initially coded by the experimenter (YY), and then recoded by a research assistant. Intercorrelations between the two coders ranged from 0.86 to 0.96 (mean = 0.93, $p < 0.01$).

2.2. Results and discussion

The Mandarin learners' looking preferences during control and test trials are shown in Table 2. The 2-way (age × trial type) ANOVA revealed only a marginally significant main effect of trial type [$F(1,51) = 3.197$, $p = .08$, $\eta_p^2 = .059$] with a medium effect size. Although a majority of each age group shifted toward the match from control to test trials (72% of 34-month-olds, 56% of 24-month-olds, and 63% of 18-month-olds), binomial tests did not reach significance. Analyses of smaller intervals of the test trials for the 2- and 3-year old groups revealed that 34-month-olds showed their strongest shift toward the matching scene during the middle third of the test trial. The 2-year-olds did not shift significantly toward the match during any interval of the test trials. Probably because a substantial number of children demonstrated word order comprehension at each age level, degree of comprehension (a test minus control difference score) was not significantly related to vocabulary size as measured by the Mandarin CDI (Tardif et al., 2008).

More subtle indications of sentence processing and understanding could be seen in the latency and switches measures. Comparing latency to first look at the matching scene during the control vs. test trials (Table 3), the 2-way ANOVA (age × trial) yielded a marginally significant main effect of trial [$F(1,34) = 3.28$, $p = .078$] and a significant effect of age [$F(1,34) = 6.10$, $p = .017$]; the interaction was not significant. Children tended to take longer to look at the match during the test trial, and 3-year-olds had faster latencies than 2-year-olds. For the switches measure, the 2-way (age × trial) ANOVA yielded only a main effect of trial [$F(1,34) = 8.35$, $p < .001$]. Both age groups, then, shifted attention more during the control trials than during the test trials (Table 4).

Although age groups and audio/video presentation for the Mandarin group were not identical to those of the English and Turkish groups in Experiment 1, we felt they were similar enough to conduct some exploratory comparisons. First, we added the Mandarin learners' data (2- and 3-year-olds only) to a 3-way ANOVA (language × age × trial type) that also included the 'percent looking full trial' data from the two language groups in Experiment 1. This ANOVA yielded a significant main effect of trial [$F(1,171) = 13.24$, $p < .001$, $\eta_p^2 = .072$] and a marginal interaction of trial and age [$F(1,171) = 3.75$, $p = .054$, $\eta_p^2 = .021$]. Additional 3-way ANOVAs including looking only during the 1st or 2nd half of the test trials also yielded significant main effects of trial, 1st half: $F(1,169) = 9.21$, $p = .003$, $\eta_p^2 = .052$; 2nd half: $F(1,169) = 8.45$, $p = .004$, $\eta_p^2 = .048$. Moreover, during the 2nd half of the trial a significant interaction of age and trial emerged, $F(1,169) = 3.85$, $p = .051$, $\eta_p^2 = .022$. Across all three languages, it appears that 3-year-olds can better maintain their attention to the match during the second half of the trial than can 2-year-olds.

Examination of latency to first look at the matching scene during control vs. test trials, the 3-way ANOVA yielded significant main effects only of trial, $F(1,219) = 7.31$, $p = .007$, $\eta_p^2 = .032$, and age, $F(2,219) = 5.41$, $p = .005$, $\eta_p^2 = .047$, with no significant interactions. Post hoc tests showed that 3-year-olds had faster latencies than 1-year-olds. For the switches measure, the combined ANOVA yielded main effects of trial [$F(1,219) = 50.29$, $p < .001$, $\eta_p^2 = .187$], age [$F(1,219) = 5.301$, $p = .006$, $\eta_p^2 = .046$], and language [$F(1,219) = 16.94$, $p < .001$, $\eta_p^2 = .134$], with 3-year-olds shifting attention more than the 1–2-year-olds and the Turkish children shifting attention more than each of the other two language groups.

In sum, we found several indications of SVO word order understanding by Mandarin child learners, including a significant decrement in shifts of attention from control to test trials and marginally significantly longer looks to the match during those test trials. These effects seem less robust than those observed for Turkish and English learners, however, which may be attributable to properties of Mandarin and/or to our sample appearing somewhat less advanced in language development. Nonetheless, these Mandarin-learning children showed some of the same sentence processing patterns as the English- and Turkish-learning children in Experiment 1: They switched attention more during test than control trials, and they tended to take longer to look at the matching scene during test than control trials. Moreover, 3-year-olds showed faster latencies than the 2-year-olds. Like the Turkish learners, however, Mandarin learners, especially in the oldest age group, displayed their most robust word order comprehension later rather than earlier in the test trial. This result is in keeping with the Mandarin input facts that NV is the modal frame for both transitive and intransitive verbs, so that Mandarin learners would need to wait to hear what follows the verb in the utterance to discover whether it is an SVO, SV, or OV sentence. However, our Mandarin learners did not shift attention during the trials to the extent displayed by the Turkish learners in Experiment 1.

3. General discussion

We chose three typologically different languages with varying degrees of flexibility in word order and different emphasis on morphology to study what young learners did when processing transitive sentences in the language's canonical word order. As predicted, we found an overall early sensitivity to word order in all three languages. The findings for English corroborate earlier studies (Hirsh-Pasek & Golinkoff, 1996); moreover, use of a preferential looking rather than a relatively more complex act-out paradigm revealed quite early sensitivity—among 1.5-year-olds learning English, young 2-year-olds learning Turkish, and almost-3-year-olds learning Mandarin—to canonical word order. However, both language and age differences were observed when considering the timecourse of transitive sentence processing.

We predicted that English learners would show comprehension early in the test trials while Turkish and Mandarin learners would show more consistent comprehension primarily later in the test trials. This prediction was largely borne out. These findings replicate and extend those of Gertner et al. (2006) and Dittmar et al. (2008), that learners of strict word order languages seem able to process transitive sentences—and so find the matching scene in an IPL task—quickly and efficiently whereas learners of case-marked languages and/or those with more word order variations take longer to process the sentence and find the matching scene in real time. Children who looked at the match consistently during the 1st half of the trial were basing their preference on just one hearing of the test sentence (i.e., during the intertrial interval), whereas children who looked at the match consistently during the 2nd half of the trial had the benefit of—and may have needed—two hearings of the test sentence.

However, our age-related prediction about early vs. late matching was not borne out. Contrary to prediction, English-speaking 1- and 2-year-olds displayed more consistent matching of sentence and scene during the 1st half of the test trials than during the 2nd half whereas 3-year-olds demonstrated consistent matching throughout the trials. Thus, even 1-year-old English learners seem able to process the sentence quickly enough to find the matching scene within 3 s; the less consistent matching that they and the 2-year-olds displayed during the 2nd half of the trial could be attributed to distractability and/or loss of interest in the videos.

The latency measure indicated that children took longer to look at the matching scene during test trials, when they had heard and were likely processing a directing audio, than to look at the same scene during control trials, when their looking preferences were likely guided primarily by stimulus salience. This was a robust finding with neither language nor age effects and might be taken as a minimum indication that the linguistic stimulus indeed influenced children's processing of the visual events. The overall age effects were also straightforward. As predicted, older children exhibited shorter latencies in looking at the matching scene compared to younger children. These findings extend those of Fernald et al. (2008), adduced from investigations of word learning and recognition, to investigations of sentence comprehension: Older children are faster language processors than younger children.

Finally, we predicted that English learners would switch attention less frequently than Turkish or Mandarin learners, because switches of attention might signal uncertainty during processing, and English learners were predicted to be the most certain about matching sentences with scenes because word order is the most reliable cue to semantic relations in English. Our findings were only slightly different: Turkish learners indeed switched attention more frequently than either English or Mandarin learners, who did not differ from each other. This effect supports the claims that word order has diminished reliability as the sole cue to Turkish agent–patient relations and that Turkish children are in some way (implicitly) aware of this diminished reliability for simple sentences in NNV order. It is interesting that Mandarin learners do not switch attention any more frequently; this may suggest that the existence of varied word orders in one's language does not limit the reliability of the canonical order as much as the presence of case markers does. More detailed examinations of children's input in Turkish and Mandarin are needed in order to compare the reliability of word order cues in both languages.

We also predicted that older children would show fewer switches of attention than younger ones, because younger children are expected to be less certain about the sentence-scene match. This prediction was not borne out. Both English- and Mandarin-speakers (but not Turkish ones) showed *increases* in their frequency of switching attention with age. As with the latency measure, however, the switches measure may actually indicate different types of attention shifts for different age groups. As currently configured, this measure does not tell us where the children were shifting their attention *to*. Turkish learners, for example, may switch attention more between matching and non-matching scenes, suggesting uncertainty with sentence interpretation, whereas other children may switch attention more between the matching scene and looking away, suggesting boredom rather than uncertainty. Thus, it is important to measure direction of attention shift in future studies.

In sum, languages with noun omissions appear to elicit slower processing of transitive sentences with 2-NPs by young learners. Good comprehension was found primarily during the latter parts of the test trials in both Turkish and Mandarin, even though these differ on canonical word order and presence/absence of case markers. Such slower processing can be tied to noun omissions and variable word order. Because objects may occur in the early portions of sentences in both Turkish and Mandarin especially in non-canonically ordered sentences with omitted subjects, like (7) above, there is greater indeterminacy about how a first noun should be assigned. Switches of attention, if these may be taken as indications of uncertainty, seem more prevalent in Turkish learners, however, and may be a result of that language's usual reliance on case markers, which were absent in this study, for designating agent–patient relations. Still, Turkish was also the only SOV language studied here, so we cannot be sure whether specific order or case markers—or some combination—might be yielding these results. It will be important to compare SVO languages with and without case markers (e.g., English vs. Polish), as well as SOV and SVO languages with case markers (e.g., Turkish vs. Polish) to distinguish these effects.

A question frequently raised in the long-standing study of children's comprehension of sentences in their language's canonical (or not) word order concerns the degree to which the children are really using word order—i.e., processing the entire sentence—when they enact or match such sentences. One alternative is that children are 'just' matching the 1st NP with the most agent-like, causally instigative character in the scene, without actually processing the rest of the sentence (Chan et al., 2010; Slobin & Bever, 1982). Our participants' performance with some specific verbs speaks against this strategy, however. For example, the agents of *wash* and *hug* are most active while the patients of *tickle* and *ride* are most active; however, both English and Turkish 3-year-olds performed well with *wash* and *tickle* (65% of English learners and 59% of Turkish learners shifted to the match during test for *tickle* and 77% of English learners and 56% of Turkish learners did so for *wash*). Moreover, Turkish-learning 2-year-olds performed equally poorly with both *tickle* (46% shift to match) and *wash* (42% shift to match), and English-learning 2-year-olds performed well with both *hug* (56% shift to the match) and *ride* (66% shift to match). Thus, our participants showed no evidence of adhering to a strategy in which they simply try to match the 1st NP in the sentence with the scene in which that NP is most active.

Although the nouns and verbs in these sentences were familiar ones, the actual renditions were novel (few toddlers have seen upright horses pushing or tickling 5-foot-tall bluebirds, nor bluebirds hugging or pulling horses). Thus, children had to make some extensions from their usual experiences with these nouns and verbs in order to perform successfully, and they had to understand their language's canonical transitive word order as differing at least somewhat from any transitive sentences they had thus far heard. We suggest that children's ability to extend words and sentence frames to new renditions is a continuation of the language processing begun in infancy. Infants begin tracking distributional information in their auditory input at least by 6 months of age (Gervain, Nespor, Mazuka, Horie, & Mehler, 2008; Nazzi, Kemler-Nelson, Jusczyk, & Jusczyk, 2000). Moreover, toddlers 12–18 months of age are able to use the function words—and morphology—of their language to recognize and even categorize co-occurring novel or familiar content words (Höhle, 2009). The acquisition of a given language's ordering patterns thus begins in infancy, and these ordering patterns appear highly learnable by infants. Our findings highlight that children's ease of processing such patterns is affected by their consistency in the language they are learning. Finally, these findings may also be consistent with recent demonstrations that (somewhat older) children are able to extract modal (albeit not majority) patterns in their linguistic input and use these patterns with considerable systematicity (Hudson Kam & Newport, 2005; Singleton & Newport, 2004). Possibly analogously, at least early in development, young children learning Mandarin or Turkish may take the 'only moderately frequent' word order pattern of their language to be systematic and regular.

In conclusion, we have conducted one of the first studies investigating how transitive sentence processing varies in children during the earliest years of engagement in such processing and varies in children who have been exposed to three typologically different languages. Using the IPL task and multiple dependent measures, we have observed that children learning strict word order languages such as English show temporally earlier matching of sentence and scene than children learning case-marked and/or variable word order languages, such as Mandarin and Turkish. Moreover, children learning Turkish display significantly more switches of attention during transitive sentence processing than children learning English or Mandarin, possibly indicating differences in their certainty of the sentence-scene match. And, corroborating Fernald et al. (2008), (3)-year-olds are faster sentence processors than younger children (1-year-olds). Finally, we have also found a language-general tendency of early acquisition of a language's most typical word ordering pattern. Even in languages that regularly use other devices such as inflectional morphology to indicate argument relations, the canonical sequencing of words can be employed to identify agents and patients by children in their 2nd and 3rd years of life.

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