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The Competition Between Processing and Discourse-Pragmatic Factors in Children's and Adults' Production of Adverbial *When*-Clauses

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Abstract

Purpose: This is the first study to investigate the combined effects of processing-based factors (i.e., clause length and clause order) and discourse-pragmatic factors (i.e., information structure) on children's and adults' production of adverbial *when*-clauses.

Method: In a sentence repetition task, 16 three-year-old and 16 five-year-old children as well as 17 adults listened to and watched an animated story and then were asked to repeat what they had just heard and seen. Each story contained an adverbial *when*-clause and its main clause. The sentences were manipulated for their clause order, information structure and clause length.

Results: Adults tended to change main-*when* clause orders to *when*-main in their repetitions and they showed a strong preference for the given-new order of information. In contrast, three-year-olds tended to change *when*-main clause orders to main-*when* and they showed a preference for the new-given order of information. In addition, three-year-olds tended to produce short-long clause orders irrespective of what they had heard whereas adults produced both short-long and long-short orders in line with the input. In general, five-year-olds were more adult-like in their production compared to three-year-olds.

Conclusions: Young children were strongly affected by processing-based factors in their production of complex sentences. They tended to order main and *when*-clauses in a way that requires less planning and processing load. However, they have not yet attained an adult-like sensitivity to discourse-pragmatic factors.

Introduction

In English, complex sentences allow some flexibility in their ordering of the adverbial and main clause. Compare examples (1) and (2) below. The adverbial *when*-clause can precede or follow its main clause. Similar patterning occurs for other types of adverbial clauses such as temporal (*before/after*), causal (*because*) and conditional (*if*) clauses. However, there appear to be differences in how these two orders are processed that reflect competing processing-based and discourse-pragmatic constraints (Diessel, 2005).

(1) [Charlotte was cooking a meal]$_{MAIN}$, [when John came home]$_{ADVERBIAL}$.

(2) [When John came home]$_{ADVERBIAL}$, [Charlotte was cooking a meal]$_{MAIN}$.

Previous studies have tested predictions derived from theoretical models of language processing, discourse-pragmatics and semantics to explore why one order may be easier to process than the other, and how this might change over development (e.g., Blything & Cain, 2016, 2019; De Ruiter et al. 2018, 2020; Junge et al., 2015). However, most of these studies have looked at comprehension only. Less attention has been paid to complex sentence production, which involves sentence planning and articulation (but see Silva (1991) and Blything & Cain (2019)). In particular, there are very few experimental studies that have investigated children's production of *when*-clauses, which are one of the earliest and most frequent types of adverbial clauses in children's speech (Diessel, 2004). The present study aims to fill these gaps by investigating how processing-based and discourse-pragmatic factors influence children's and adults' production of adverbial *when*-clauses and how this might change over development.

Processing-based factors

Adapting Hawkins' parsing theory (Hawkins, 1994, 2004), Diessel (2005) proposed that final adverbial clauses are easier to process than initial adverbial clauses, as they have a shorter recognition domain. Specifically, for the final adverbial clause as in example (1) it takes a listener two words, *meal* and *when*, to recognise that the main clause is followed by an adverbial clause. However, for the initial adverbial clause as in example (2), a listener has to process the whole adverbial clause to recognise how it is linked to the main clause. Similarly, initial adverbial clauses are proposed to be harder for speakers because they require a speakers' early commitment to a complex sentence, which involves a large amount of utterance planning (Diessel, 2005; Wasow, 1997). In contrast, final adverbial clauses allow speakers to plan utterances one clause at a time.

In addition to clause order, the length of the linguistic elements has also been identified as an important factor influencing how speakers structure their utterances. It has been suggested that, in English (a head-initial language), speakers prefer placing short elements before long elements, as

longer elements are more difficult to plan (e.g., Arnold et al., 2000; Stallings et al.,1998 – although the reverse pattern has been observed for head-final languages such as Japanese, e.g. Yamashita & Chang, 2001). In other words, postponing longer elements can give speakers more time to retrieve and plan the more complex element while uttering the shorter (and less complex) element. At the same time, uttering short before long elements is also easier for hearers to parse, as short elements are easier to keep in memory than long elements, allowing later produced information to be more easily integrated with earlier occurring information (Arnold et al., 2000; Hawkins, 1994).

In developmental work, mixed results have been reported for children's sensitivity to clause order. Diessel's (2004) corpus study found that children at the age of three spontaneously produced very few initial adverbial clauses, preferring final adverbial clauses that carried a lower processing load to plan and produce. Silva (1991) investigated the production of *when*- and *while*- clauses in elicited narratives and found that children (4;01-8;11) produced slightly more initial adverbial clauses than final adverbial clauses whereas both older children (9;0-11;11) and adults showed a strong preference for initial *when*-clauses. These studies suggest there may be a developmental change in preference. Younger children appear to show a stronger preference for final *when*-clauses (lower processing load) whereas older children and adults prefer to use initial *when*-clauses (to present backgrounded and/or given information). However, a recent production study using sentence repetition and blocked elicited production tasks looking at *before*- and *after*- clauses found neither final nor initial adverbial clauses easier for children (3;05-6;08) (Blything & Cain, 2019). Similarly, recent comprehension studies found no independent main effect of clause order (e.g., Blything & Cain, 2016; De Ruiter et al. 2018, 2020; Junge et al., 2015). These mixed results could be in part due to varying methodologies used and different types of adverbial clauses examined. However, they demonstrate the need for further studies to increase our understanding of the role of processing load in determining production of adverbial clauses across development.

To our knowledge, there is only one corpus study looking at the impact of constituent length on children's production of complex sentences. This study focussed on young children's choice of

dative alternations (De Marneffe et al., 2012). They found that children tended to place long noun phrases later leading to double object constructions (e.g., *and she gives them **some broth without any bread***) whereas short ones were placed earlier leading to prepositional dative constructions (e.g., *I wanna give **that** to Poy now*). However, length in this study was conflated with other variables such as pronominality and information status. It is unclear whether the short-before-long pattern still holds when all other variables (e.g., pronominality, information status) are controlled as this has not been tested experimentally at the complex-sentence level.

Discourse-pragmatic factors

It is commonly assumed that speakers show a strong preference for placing given elements before new elements (e.g., Arnold et al., 2000; Clark & Haviland, 1974; Haviland & Clark, 1974). Specifically, given information is information that has occurred in previous perceptual and/or discourse contexts whereas new information has not occurred previously. If given information precedes new information, hearers can retrieve a matching antecedent in memory and integrate the new information with it quickly. Moreover, it allows speakers more time to activate and plan new information (Arnold et al., 2000; Haviland & Clark, 1974). Information structural properties often interact with aspects of the wider discourse structure. One specific instance can be seen in question-answer sequences where information presented in the question functions to establish an information focus that is satisfied in the response. Information repeated from the question to response is considered to be given (e.g., *When did Charlie hurt his leg? Charlie hurt his leg$_{[GIVEN]}$ when he jumped off the step$_{[NEW]}$*)[1]. To gain a full understanding of the role of information structural properties on adverbial clause order, it would be necessary to consider a range of different discourse-pragmatic scenarios. However, the focus in the current paper is restricted to the role of information structural properties on the ordering of adverbial *when*-clauses to describe two co-occurring events.

[1] We thank an anonymous reviewer for pointing out the role of question-answer sequences and their relation to information structure and information focus.

Investigating the interaction between information structure and clause order, the pre-supposition hypothesis proposes that the given-new order of information is easier to process only when given information is expressed by an adverbial clause (e.g., Diessel, 2013; Verstraete, 2004; Scholman et al., 2022). The basic idea is that when the adverbial clause occurs in the initial position, it tends to present pragmatically presupposed information (i.e., information that is part of the common ground, or given) and therefore can help to establish the link between previous discourse and the main clause (unlike in the question-response example above where the *when*-clause provides a response to the question, and encodes new information).

Junge et al. (2015) tested three- and five-year old children's and adults' sensitivity to information structure in their comprehension of *when*-clauses and found that young children were sensitive to information structure, but not to the clause order[2]. Specifically, in an act-out study, participants first heard a pre-recorded story and then acted out the story based on the retrieval of what they had heard. Each story consisted of three intransitive introductory sentences (to establish one event as 'given', e.g., *The sheep is swimming, he's swimming, he's swimming!)* followed by the test sentence that described the same 'given' event plus another 'new' event (e.g. *[The cat is driving]*$_{\text{NEW}}$ *[when the sheep is swimming]*$_{\text{GIVEN}}$.). The test sentence consisted of a *when*- and a main clause with their clause order (e.g., *when*–main, main–*when*) and information structure (i.e., one clause contained the event mentioned in the introductory sentences, the other referred to a new event; given–new, new–given) manipulated. The results show that regardless of the clause order of *when*- and main clauses, children tended to change the order of information in their act out to given-new when they heard the story describing the events with a new-given order. However, adults

[2] Of note, Junge et al. (2015)'s findings differ from that of De Ruiter et al. (2020), in which children of similar age comprehended *after-*, *because-*, and *if*-sentences best when given information preceded new information and was expressed by an initial adverbial clause. We suggest that the difference could be partially because the adverbial clauses used in De Ruiter et al. (2020) encoded consecutive events. Semantically (i.e., the "order-of-mention" strategy, describing events in the order in which they occur), an initial position is preferred by these three types of adverbial clauses. However, *when*-clauses in Junge et al. (2015) encoded events that could be interpreted as sequential or simultaneous. Without the semantic-level support, children's preference for initial adverbial clauses was not shown.

were sensitive to both information structure and clause order. They tended to change the order of events in their act out to *when*-main when they heard the reverse, and the initial *when*-clauses in their act out tended to carry given information.

Unlike in comprehension, several production studies suggest that young children might not have developed an adult-like awareness of information structure. As mentioned previously, Diessel's (2004) corpus study found that three-year-old children barely use initial adverbial clauses. He argues that young children's lack of use of initial adverbial clauses could be because the discourse-pragmatic function that initial adverbial clauses serve is not relevant in early child speech. Similarly, Silva (1991) found that children aged up to eight years produced fewer initial *when*- and *while*-clauses in elicited narratives compared to older children and adults. She argued that adults overwhelmingly used initial *when*-clauses to provide background information, and suggested that younger children's lower use of initial adverbial clauses may reflect their still- developing sensitivity to listener needs. Finally, several production studies at the phrasal level reported that young children preferred to name new objects before given ones (e.g., Baker & Greenfield, 1988; Narasimhan & Dimroth, 2008).

To summarise, processing-based factors and discourse-pragmatic factors can sometimes compete with one another in determining the ordering of main and adverbial clauses in complex sentences. From the processing perspective, final adverbial clauses are expected to be easier to process as linking a final adverbial clause with an initial main clause requires less processing load and utterance planning. In contrast, from the discourse-pragmatic perspective, initial adverbial clauses are favoured as they tend to convey given information (noting the different pattern observed in question-answer sequences). So far there is no compelling evidence to uniquely support either hypothesis regarding preferred clause order for children (e.g., Blything & Cain, 2019; Diessel, 2005; Junge et al., 2015). Similarly, mixed results are found for children's sensitivity to information structure. In comprehension studies, young children were more similar to adults in showing a preference for the given before new order of information (e.g., Junge et al., 2015). However, several

production studies reported that young children have not attained an adult-like sensitivity to the ordering of information structure in the sentence (e.g., Diessel, 2004; Silva, 1991).

In the present small-scale study, we investigated whether processing-based and discourse-pragmatic properties that seemed to affect comprehension of adverbial *when*-clauses in Junge et al. (2015) can apply to complex sentence production. In Junge et al.'s (2015) comprehension study, children needed to retrieve the events they had heard from memory to perform the actions. However, as the task was an act-out task, they did not need to recall the precise sentence structures they had heard. Their findings suggest that the retrieval process was affected by the information status of the events, such that children tended to retrieve the events in a given-new order (discourse-pragmatic factors). However, in production, sentence planning and articulation are involved. In this case, children whose processing capacities are more limited than those of adults may prefer clause structures that require less planning to articulate (i.e., processing-based factors: clause order and clause length) to reduce processing demands. In the current study, we adopted a sentence repetition task. Sentence repetition is known to involve both encoding of the semantics of the heard sentence and reproduction of the meaning from memory, so is an effective way of tapping into speakers' linguistic knowledge and representations (e.g., Lust et al., 1996; Potter & Lombardi, 1990). The following research questions were addressed. As a function of clause order, information order and clause length in the input, do children and adults show any differences in their repetition of (i) clause order, (ii) information order and (iii) clause length?

Methods

Participants

Sixteen children between 3;0 and 3;2 (M = 36.5months, SD = 0.73; 11 girls) and 16 children between 5;0 and 5;5 (M = 62.13months, SD = 1.71; 6 girls) were included in the study[3]. They were all reported to be typically developing monolingual speakers of English. A further 16 children were tested but

[3] As this study was designed and conducted prior to recent advances in the understanding of considerations of power, and specifically power analysis for mixed effects models (Brysbaert & Stevens, 2018), no formal power analyses were conducted.

had to be excluded from the analyses because they chose not to play (N=10), they did not complete sufficient trials (i.e., they repeated only one of the three trials per condition; N=5), or produced ambiguous sentences (i.e., they repeated only one of the two events in each trial; N=1). In addition, 17 adult native speakers of English (M = 20.53years, SD = 2.18; 15 women; primarily undergraduate students) were tested as controls. All participants were tested in the university Child Study Centre or in their home (1 child).

Materials

The stimulus materials consisted of test sentences and their corresponding animated silent films. The test sentences consisted of an adverbial *when*-clause and a main clause for which the order was manipulated (i.e., WHEN-MAIN vs. MAIN-WHEN). The *when*- and main clauses also differed in length and in their information status. Length was determined in terms of number of words and syllables for each clause (i.e., LONG-SHORT vs. SHORT-LONG). The short clause consisted of 4 words/5 syllables, while the long clause consisted of 6 words/10 syllables. The information status of the clauses was determined by the givenness or newness of the information in the clause (i.e., GIVEN-NEW vs. NEW-GIVEN). If the clause had been produced in the immediately preceding discourse context, it was classified as GIVEN. If it had not, it was classified as NEW.

The three manipulated factors, clause order (WHEN-MAIN, MAIN-WHEN), information order (GIVEN-NEW, NEW-GIVEN), and clause length (LONG-SHORT, SHORT-LONG), resulted in eight conditions. Each condition consisted of one simple introductory sentence (repeated once more with the subject pronominalised) followed by three test sentences that included given information from the introductory sentences. Table 1 provides examples (one introductory and one test sentence) from each condition.

Table 1

Examples of each condition

Clause Order	Information Order	Clause Length	Sentences
WHEN-MAIN	GIVEN-NEW	SHORT-LONG	Pig is swimming, oh he's swimming. (Introductory)
			When Pig is swimming, Little Panda is drinking very fast. (Test)
WHEN-MAIN	GIVEN-NEW	LONG-SHORT	Crocodile is crying so badly. Oh he's crying so badly.
			When Crocodile is crying so badly, Brown Bear is sleeping.
WHEN-MAIN	NEW-GIVEN	SHORT-LONG	Mister Zebra is pushing really hard, oh he's pushing really hard.
			When Sheep is drawing, Mister Zebra is pushing really hard.
WHEN-MAIN	NEW-GIVEN	LONG-SHORT	Brown Horse is running. Oh, he's running.
			When Donkey is talking very loudly, Brown Horse is running.
MAIN-WHEN	GIVEN-NEW	SHORT-LONG	Miss Duck is paddling, oh she's paddling.
			Miss Duck is paddling, when Bunny is hopping very slowly.
MAIN-WHEN	GIVEN-NEW	LONG-SHORT	Mister Fish is knocking very loudly. Oh he's knocking very loudly.
			Mister Fish is knocking very loudly, when Snake is crawling.
MAIN-WHEN	NEW-GIVEN	SHORT-LONG	Hamster is sneezing really badly, oh he's sneezing really badly.
			Bird is flying high, when Hamster is sneezing really badly.
MAIN-WHEN	NEW-GIVEN	LONG-SHORT	Cow is sliding, oh she's sliding.
			Blue Parrot is laughing very loudly, when Cow is sliding.

A full list of eight conditions is provided in Table S1 in the Supplemental Material. In each condition, four intransitive verbs and four animal agents were used. The verbs were selected based on the most frequent verbs found in the CHILDES English Manchester Corpus (Theakston et al., 2001). Familiarity with the animal agents was tested in the warm-up session. Each condition was presented in one block. The order of presentation of each condition was counterbalanced and the order of the test sentences within each condition was pseudo-randomised. In total, eight conditions consisted of eight introductory sentences and 24 test sentences. They were all pre-recorded by a young female native speaker of British English.

In addition, each test sentence corresponded to two animated silent films playing simultaneously on the screen, each depicting one of the two intransitive actions of the *when*- and main clause. The film animations were created in Anime Studio Pro. There was a delay of 5 seconds between the audio-recorded test sentences and the films to avoid the child simply repeating what s/he had just heard in the audio. The side of presentation of the films for *when*- and main clauses was counterbalanced across test sentences.

Procedure

Before the start of the target trials, we provided a warm-up phase to familiarise participants with the task. The experimenter first asked participants to name animals on the computer screen to ensure that they were familiar with the animals later used in the stories. Second, participants were asked to repeat simple sentences (e.g., *I like dogs*.), as well as complex sentences represented as pairs of pictures on the computer screen (e.g., *The girl is sticking, when the boy is washing*. *When the girl is sticking, the boy is washing*.). In addition, the experimenter made participants aware of the different possible orders of *when*- and main clause and asked them to complete the sentences in all possible orders, for example by saying "*Can you finish this: When the girl is sticking*…"[4].

[4] Although explicitly making participants aware that sentences could be manipulated in terms of their clause order could have resulted in adults (who have greater metalinguistic awareness than children) treating the task as simply one of swapping around the order of sentences they heard, the results suggest this was not the case. Both adults and children showed differences in how likely they were to reverse the order of the clauses

After the warm-up phase, participants completed the sentence repetition task. They were told to, first, listen to a story (i.e., the pre-recorded test sentence), second, to watch the silent films of the story (to avoid immediate verbatim repetition of the test sentence) and, third, to tell their caregiver what happened in the story because they could not see the film. The procedures for child and adult participants were the same, but we used a more complex distracter task (i.e., a mathematical operation such as "376+786/2") after presenting adults with the audio and video for each trial, and adults were asked to tell the experimenter what had happened.

Results

Coding

First, all verbal responses were transcribed and coded for information order (i.e., GIVEN-NEW or NEW-GIVEN) and clause order. In addition to WHEN-MAIN and MAIN-WHEN clause orders, some participants also reported the test sentences as simple sentences without any conjunction (e.g., *Pig is swimming. Frog is jumping really high*), coordinate sentences (e.g., *The pig is swimming* ***and*** *the panda is drinking*) or in some rare cases as a combination of adverbial and coordinate clauses (e.g., ***When*** *the duck is swimming,* ***and*** *the rabbit is bouncing slowly*) or two adverbial clauses (e.g., ***When*** *duck was paddling,* ***when*** *rhino was spinning.*). We coded these constructions as SIMPLE, COORDINATE, ADV-COORDINATE and ADV-ADV respectively.

Then, we compared all verbal responses to what participants had heard in the stimulus sentences (i.e., the input information order and clause order) and coded whether they made any changes for information order and clause order. If they made a change, we coded this as "1". If they did not make a change, we coded this as "0".

Last, to determine whether speakers preferred to produce clauses of differing lengths in a particular order (e.g., SHORT-LONG vs. LONG-SHORT) and whether this varied depending on what they had heard in the input, all verbal responses were coded according to the length of each clause.

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they heard as a function of our experimental manipulations, and adults, on the whole, reversed the sentences fairly infrequently.

Two measures of clause length were calculated: the number of words produced by the participant in each clause, and the number of syllables. The conjunction or coordinator was included in these counts. For each measure, we determined the participants' preference for producing different clause length patterns (e.g. SHORT-LONG, LONG-SHORT) by subtracting the length of their second clause from their first clause. A positive score indicated a LONG-SHORT sentence, a negative score indicated a SHORT-LONG sentence, and a zero score indicated an EQUAL sentence (see Figure 4 for the relative clause lengths produced in response to the different types of input sentence in each age group). This approach differed slightly from the coding of clause order and information structure order where participant responses either matched or mismatched the input and were simply coded as "0" where no change was observed and "1" for a change in these measures in comparison to the input. In contrast, when participants produced two-clause utterances, there were multiple ways in which they could respond compared to what they had heard, for example by shortening one or other clause, lengthening one or other clause, changing the order of the clauses while maintaining their respective lengths and so on. We were interested in whether participants made changes to clause length and the extent of any changes that participants made. By coding the length difference between two clauses produced by participants on a continuous scale, we were able to achieve this aim, and could also include responses where the two clauses produced were of equal length.

Data analysis

We recorded a total of 1176 verbal responses (384 from the three-year-olds; 384 from the five-year-olds; 408 from the adults). Among them, 37 verbal responses from the three-year-olds, four from the five-year-olds, and ten from the adults were uninterpretable and therefore excluded from the data analysis.

The data analyses were carried out using Generalized Linear Mixed-effects Models (GLMMs; Baayen et al., 2008) with the lme4 package (Bates, Mächler, et al., 2015) in R, version 4.2.0. To answer the three research questions, we constructed three separate models (each with a separate dependent variable: (i) clause order, (ii) information order and (iii) clause length) but used the same

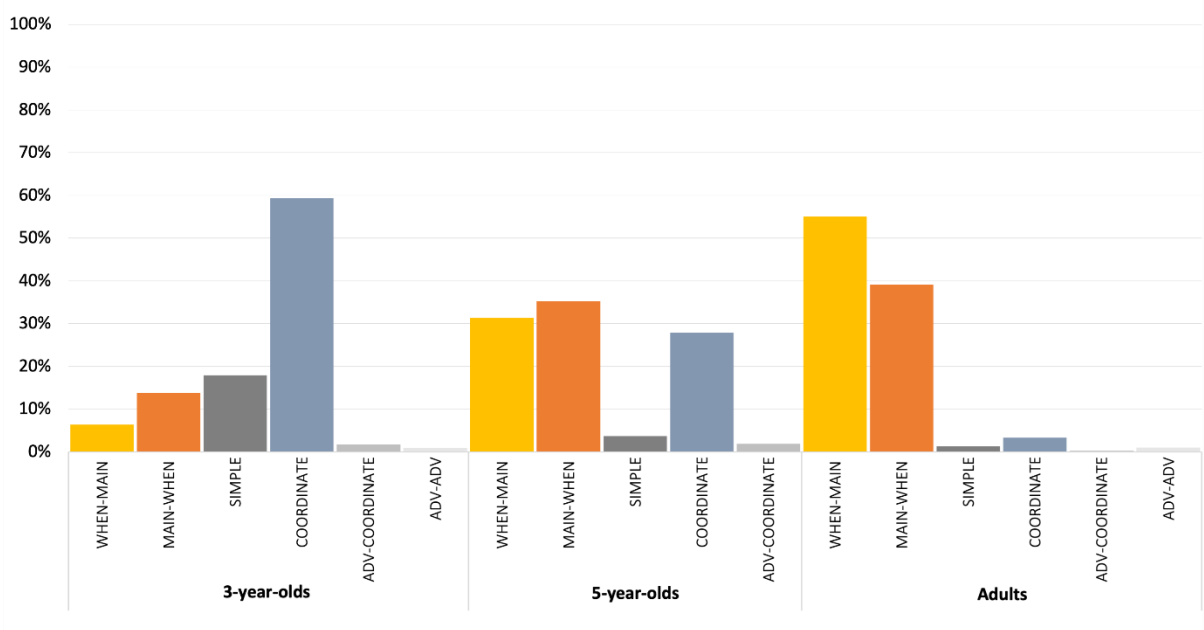
analysis strategy. For each model, the null model included random effects and random intercepts for participants and items. By-participant random slopes for the fixed effects were initially included but later removed as they resulted in lack of model convergence in most cases. Moreover, given the relatively small number of participants in this experiment, by-participant and by-item random slopes for the fixed effects should not be included to minimise the risks of creating an overfitted model (Bates, Kliegl, et al., 2015). The input information order, input clause length, input clause order, and age group were fixed effects. By default, clause order was dummy coded using "MAIN-WHEN" as a reference level, information order was dummy coded using "GIVEN-NEW" as a reference level, clause length was dummy coded using "LONG-SHORT" as a reference level, and age group was dummy coded using "3yr" as a reference level. We first compared each fixed effect to the null model one at a time with the ANOVA function, and all fixed effects that were significant retained to the next stage. We then compared each two-way interaction and three-way interaction to the model that included all significant fixed effects one at a time and all interactions that were significant entered into the final model. Finally, to directly compare the performance of all three age groups, post-hoc comparisons were conducted using the Emmeans package with Bonferroni correction (Lenth et al., 2023).

The change of clause order

The first analysis was to investigate whether participants showed a preference for one clause order over the other. Participants did not always use WHEN-MAIN or MAIN-WHEN constructions in their repetitions, and there was a large difference between the number of WHEN-MAIN and MAIN-WHEN constructions per age group. As shown in Figure 1, three-year-olds were most likely to use coordinate constructions in their repetitions. With increasing age, the proportion of WHEN-MAIN and MAIN-WHEN constructions increased.

Figure 1

Mean proportion of clause constructions produced by the three groups of participants



For the statistical analysis we only focused on participants' production of WHEN-MAIN and MAIN-WHEN constructions and analysed the factors influencing their reversals of clause order. Participants were expected to reverse the order more often for orders that pose greater processing demands and/or, for children, are less well known. By analysing the proportion of reversals, we can directly compare whether participants were more inclined to make changes to what they had heard as a function of the different input conditions. Note, however, that the proportion of reversals is directly translatable into the proportional production of the two clause orders (or information orders) as a function of the responses included in the relevant analysis; for example, a 0.25 reversal rate of MAIN-WHEN input orders means that of the responses included in this analysis (all MAIN-WHEN and WHEN-MAIN sentences) they produced MAIN-WHEN orders 75% of the time, and WHEN-MAIN 25% of the time when they had heard a MAIN-WHEN clause order in the test sentence. The final model shows that *clause order*, and the interaction between *age group* and *clause order* significantly added to the model (see Table 2). Participants' reversals of clause order were associated with the input clause order, but the reversal patterns varied across age groups.

Table 2

Significant effects and interactions in the final model of the factors influencing participants' reversals of clause order (see 'Data Analysis' section for approach to model building)

	β	*SE(β)*	*z*	*p*
(Intercept)	-0.97	0.47	-2.06	0.039
Age group_5yr	0.12	0.53	0.22	0.823
Age group_Adult	0.26	0.52	0.50	0.614
Clause order_WHEN-MAIN	**1.61**	**0.54**	**3.00**	**0.003**
Age group_5yr: Clause order_WHEN-MAIN	**-1.31**	**0.60**	**-2.18**	**0.029**
Age group_ Adult: Clause order_WHEN-MAIN	**-2.65**	**0.60**	**-4.45**	**< .001**

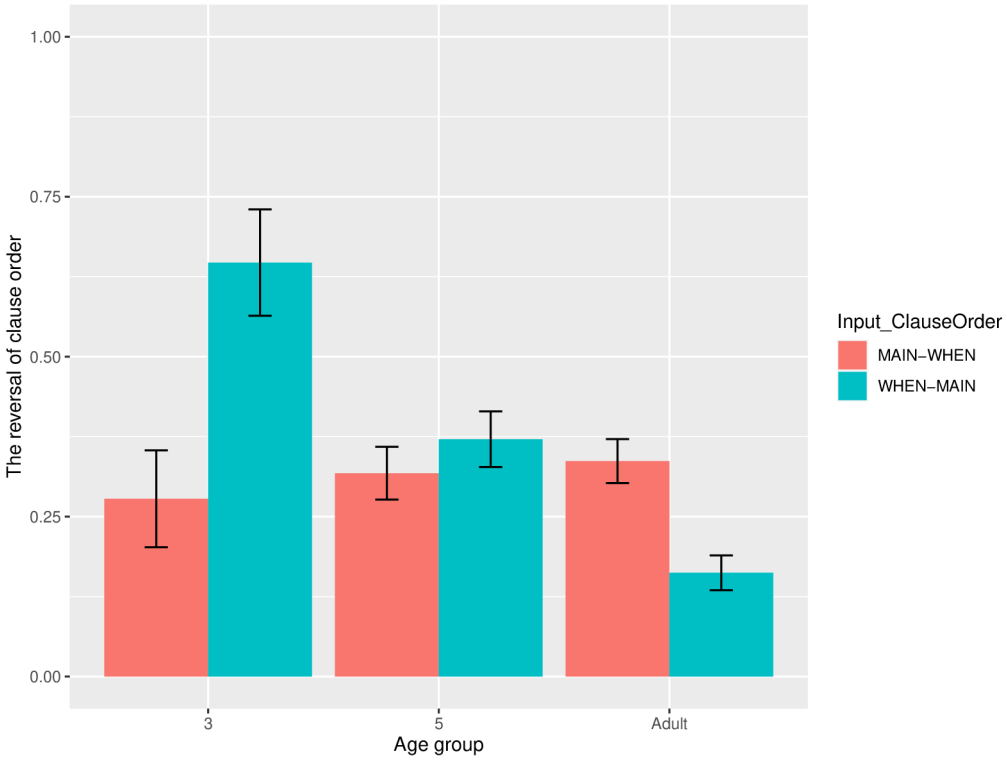
Note. Age group = Adult vs. 5yr vs. 3yr (reference level). Clause order = WHEN-MAIN vs. MAIN-WHEN (reference level). Number of observations = 698. Significant effects are highlighted in bold.

As illustrated in Figure 2, the three age groups were similar in their reversal of MAIN-WHEN inputs, but very different in their reversal of WHEN-MAIN inputs. Post-hoc comparisons confirmed the differences between the three age groups in their reversal of WHEN-MAIN inputs (see Table S3 in the Supplemental Material). When three-year-olds heard a test sentence with a WHEN-MAIN order, they showed a strong tendency to change it to a MAIN-WHEN order. A closer look at the data suggests that around half of the changes (N=10) were made by reversing the *when*-clause and its contents with the main clause (i.e., the events within each clause remained the same). For example, they changed "When Pig is swimming, Little Panda is drinking very fast" into "The Panda is drinking so fast, when the Pig is swimming." The other changes (N=12) were made by reversal of the clause type while the order of events remained the same. For example, they changed "When Pig is swimming, Tiny Froggy is jumping really high" into "The Pig was swimming, when the Frog was jumping really high". Compared to three-year-olds, five-year-olds and adults made fewer changes for test sentences with a WHEN-MAIN order. In particular, adults showed a strong preference for

WHEN-MAIN sentences (i.e. reversed them only rarely) in comparison to both child groups, while five-year-olds reversed MAIN-WHEN and WHEN-MAIN sentences at similar rates.

Figure 2

The proportion reversals of clause order by the three groups of participants according to the input clause order they heard



The change of information order

We then analysed the reversals of information order in participants' production of all types of sentences (i.e., sometimes produced as adverbial sentences but alternatively as coordinate sentences and so on). As shown in Table 3, the final model indicates that age group, information order, and the interaction between age group and information order significantly added to the model. As illustrated in Figure 3, three-year-olds were more likely to change the order of information to NEW-GIVEN when they heard a test sentence with a GIVEN-NEW order than five-year-olds, who in turn reversed GIVEN-NEW sentences to NEW-GIVEN order more than the adults. Whereas three-

year-olds were less likely to change test sentences with a NEW-GIVEN order, five-year-olds showed the opposite pattern and were marginally more likely to change the order of information from NEW-GIVEN to GIVEN-NEW than vice versa. Adults made fewer reversals overall than both child groups but like the five-year-olds they preferred to reverse sentences to GIVEN-NEW, making very few reversals of GIVEN-NEW inputs. Post-hoc comparisons confirmed the results (see Table S4 in the Supplemental Material).

Table 3

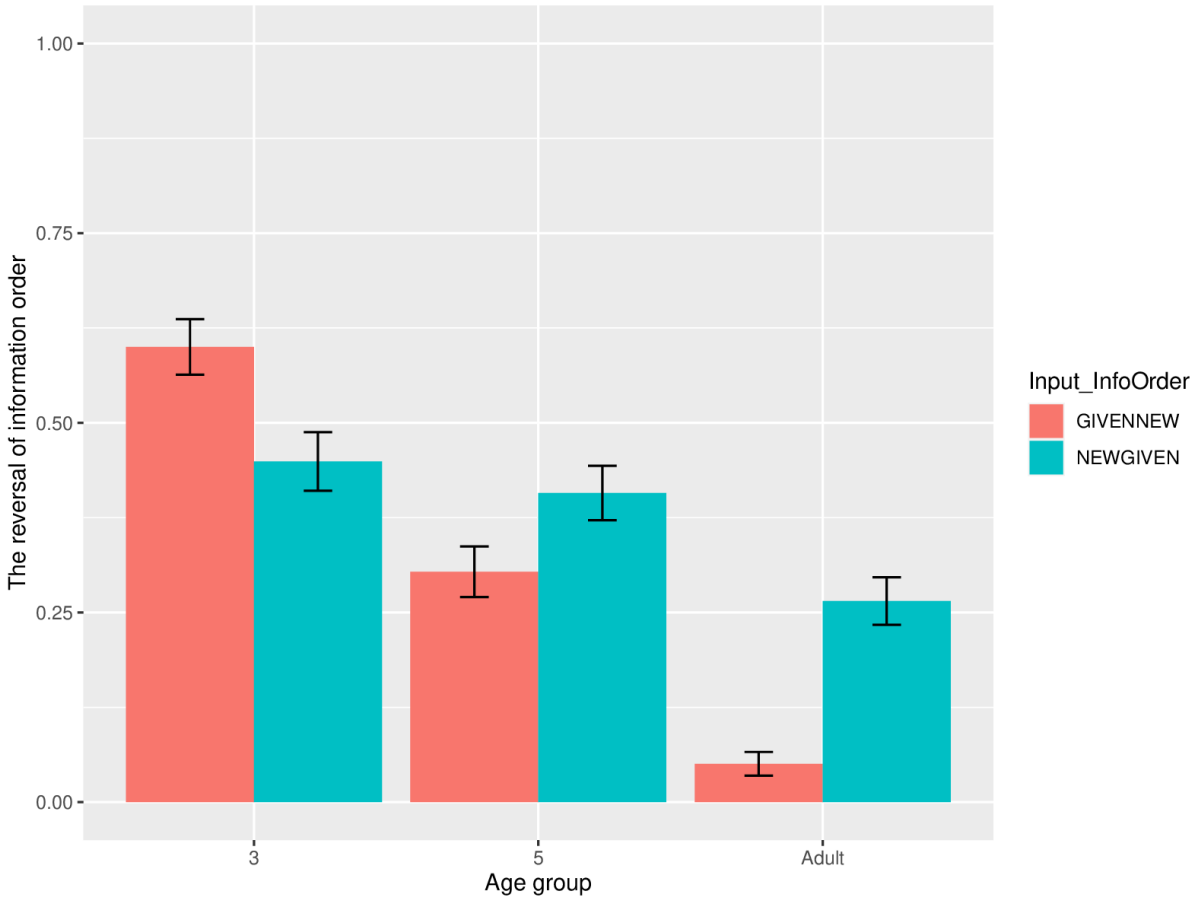
Significant effects and interactions in the final model of the factors influencing participants' reversals of information order (see 'Data Analysis' section for approach to model building)

	β	*SE(β)*	*z*	*p*
(Intercept)	0.44	0.25	1.78	0.075
Age group_5yr	**-1.39**	**0.33**	**-4.21**	**< .001**
Age group_Adult	**-3.64**	**0.44**	**-8.30**	**< .001**
Information order_NEW-GIVEN	**-0.64**	**0.27**	**-2.41**	**0.016**
Age group_5yr: Information order_NEW-GIVEN	**1.14**	**0.32**	**3.53**	**< .001**
Age group_ Adult: Information order_NEW-GIVEN	**2.69**	**0.44**	**6.18**	**< .001**

Note. Age group = Adult vs. 5yr vs. 3yr (reference level). Information order = NEW-GIVEN vs. GIVEN-NEW (reference level). Number of observations = 1125. Significant effects are highlighted in bold.

Figure 3

The proportion reversals of information order by the three groups of participants according to the input information order they heard



The change of clause length (in words)

Lastly, we analysed the changes of clause length (in words) in participants' production of all types of sentences. The final model shows that *age group*, the interaction between *age group* and *clause length*, and the three-way interaction between *age group*, *clause length* and *information order* significantly added to the model (see Table 4)[5].

[5] The results revealed that the patterns of changes of clause length in syllables was similar to that of in words. Due to space limitations, only the results from clause length in words are reported in the main text. Table S2 in the Supplemental Material provides the results from clause length in syllables.

Table 4

Significant effects and interactions in the final model of the factors influencing participants' changes of clause length (in words) (see 'Data Analysis' section for approach to model building)

	β	*SE(β)*	*t*	*p*
(Intercept)	-0.94	0.21	-4.44	< .001
Age group_5yr	**1.03**	**0.29**	**3.50**	**< .001**
Age group_Adult	**2.21**	**0.29**	**7.61**	**< .001**
Clause length_SHORT-LONG	-0.05	0.25	-1.20	0.843
Information order_NEW-GIVEN	0.32	0.26	1.24	0.217
Age group_5yr: Clause length_SHORT-LONG	**-1.04**	**0.35**	**-3.00**	**0.003**
Age group_ Adult: Clause length_SHORT-LONG	**-2.71**	**0.34**	**-7.87**	**< .001**
Age group_5yr: Information order_NEW-GIVEN	-0.12	0.35	-0.33	0.744
Age group_ Adult: Information order_NEW-GIVEN	**-0.98**	**0.35**	**-2.81**	**0.005**
Clause length_SHORT-LONG: Information order_NEW-GIVEN	-0.13	0.36	-0.36	0.720
Age group_5yr: Clause length_SHORT-LONG: Information order_NEW-GIVEN	0.53	0.50	1.07	0.284
Age group_Adult: Clause length_SHORT-LONG: Information order_NEW-GIVEN	**1.93**	**0.49**	**3.93**	**< .001**

Note. Age group = Adult vs. 5yr vs. 3yr (reference level). Clause length = SHORT-LONG vs. LONG-SHORT (reference level). Information order = NEW-GIVEN vs. GIVEN-NEW (reference level). Number of observations = 1125. Significant effects are highlighted in bold.

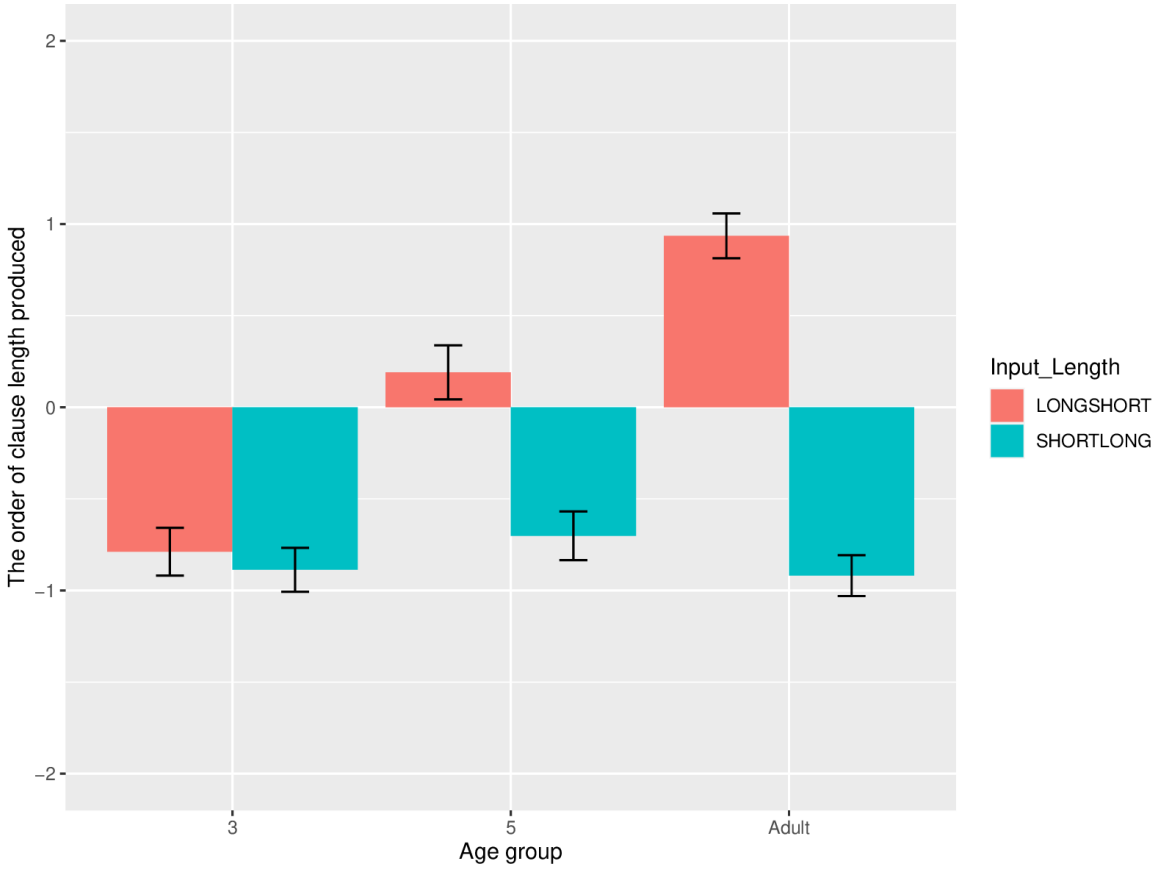
To interpret the three-way interaction, we first looked at the participants' changes of clause length across the three age groups. Recall that the input short clause consisted of 4 words and the input long clause consisted of 6 words. Thus, exact repetition of an input LONG-SHORT sentence should be scored as "2", and an input SHORT-LONG sentence scored as "-2". As shown in Figure 4, the three groups were similar in their response to SHORT-LONG utterances. However, when three-year-olds heard a test sentence with a LONG-SHORT order, they tended to change the order of clause length to SHORT-LONG (i.e., a negative score). For example, they changed "When Crocodile is

crying so badly [LONG], Big Wolf is sweeping [SHORT]" into "When Crocodile was crying [SHORT], Big Wolf was doing the sweeping [LONG]".

Figure 4

The order of clause length (in words) produced by the three groups of participants according to the input clause length they heard

Note. Positive score = LONG-SHORT sentence; Negative score = SHORT-LONG sentence



Five-year-olds did not change the order of clause length from LONG-SHORT to SHORT-LONG order like the three-year-olds. Instead, they reduced the length difference between the two clauses for LONG-SHORT targets. A closer look suggested that the reduction of length difference was achieved by shortening the long clause but extending the short clause (e.g., "When the Crocodile is crying[5 words], the Big Fox is sweeping[5 words]"). Post-hoc comparisons confirmed the effect of input

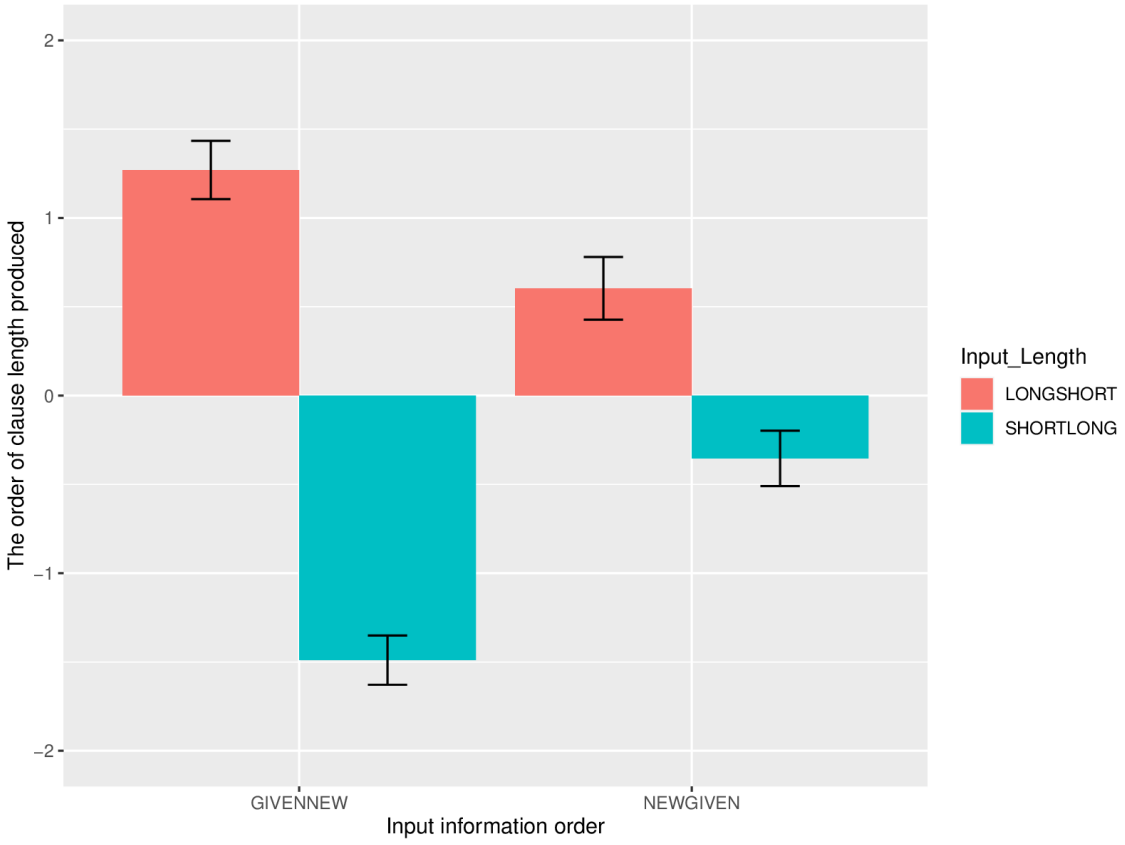
clause length on each age group's changes of clause length (see Table S5 in the Supplemental materials).

Unlike children, adults' changes of clause length were less associated with the input clause length (overall, their utterances tended to mirror what they had heard in terms of the relative length of the two clauses and they produced more LONG-SHORT utterances than both child groups), but more with the input information order. As shown in Figure 5, adults made fewer changes for clause length when they heard test sentences with a GIVEN-NEW order. In contrast, they tended to reduce the length difference between the two clauses for test sentences with a NEW-GIVEN order.

Figure 5

The order of clause length (in words) produced by adults according to the input clause length and input information order they heard

Note. Positive score = LONG-SHORT sentence; Negative score = SHORT-LONG sentence



Moreover, the length difference was reduced more for test sentences with a NEW-GIVEN and a SHORT-LONG order. This was also achieved by extending the short clause and shortening the long clause. The post-hoc comparisons further suggested that the difference between adults and five-year-olds in their repetition of LONG-SHORT inputs diminished in their production of sentences with a NEW-GIVEN order since both age groups apparently adopted a similar strategy to reduce the length difference between the two clauses. The results suggest that clause length has a stronger impact on children's production of complex sentences, especially three-year-olds, while information order is a stronger determinant in adults' production of complex sentences.

Discussion

This small-scale study investigated whether three- and five-year-old children as well as adults were sensitive to processing-based factors (i.e., clause length and clause order) and discourse-pragmatic cues (i.e., information order) in their repetition of *when*-clauses and their main clauses, as presented in a series of declarative sentences.

First, our results show that three-year-old children tended to use coordinate constructions in their repetitions whereas five-year-old children were more adult-like in using more adverbial sentence constructions. We suggest that children as young as three-years-old already have some knowledge of the form-function relations encoded by *when*- and main clauses, as they are able to use an alternative syntactic construction (e.g., *The pig is swimming **and** the panda is drinking*.) to indicate two events that occurred simultaneously, that is, the temporal relation encoded in complex sentence constructions. However, *when*-clauses could be more difficult for young children to plan, as they have a syntactic and semantic dependency relation with their main clauses. In contrast, coordinate constructions are easier as they can be planned successively (Diessel, 2004).

When focussing in on participants' production of *when*- and main clauses, we found that three-year-old children showed a preference for producing MAIN-WHEN constructions but this preference decreased with age. This could be attributed to the fact that younger children have lower

processing capacities and therefore show a stronger preference for MAIN-WHEN constructions that are easier to plan, in line with processing-based accounts (Hawkins, 1994, 2004; Diessel, 2005). In contrast, adults preferred WHEN-MAIN constructions. Their higher proportion of WHEN-MAIN sentences can be linked to the GIVEN-NEW order they preferred. That is, adults were more likely to mirror what they had heard when given information preceded new information and was expressed by an initial adverbial clause. Our adult data add to the existing literature in confirming support for the presupposition hypothesis, in line with the adult comprehension data from Junge et al., (2015) and De Ruiter et al. (2020).

We now take a closer look at the impact of information structure on children's production. Three-year-olds preferred using the NEW-GIVEN order in their production of all types of sentences whereas five-year-olds were more adult-like in producing slightly more GIVEN-NEW sentences. These findings are consistent with earlier production studies at the phrasal level (e.g., Narasimhan & Dimroth, 2008), but demonstrate that this preference for NEW-GIVEN order extends to young children's early production of complex sentences. However, our results differ from Junge et al. (2015)'s comprehension findings, in which children preferred to act out events in a GIVEN-NEW order regardless of the order of the clauses they heard. These contrasting findings suggest that there could be some differences between children's sensitivity to processing-based and discourse-pragmatic cues in comprehension and production. In sentence comprehension, children make use of their developing knowledge about prototypical sentence structures to predict and interpret the incoming speech stream (e.g., Noble et al., 2016). However, the reliance on more global cues (e.g., given-before-new) vs. local cues associated with specific sentence structures may be influenced by the task children are asked to perform. In De Ruiter et al.'s (2020) study of *before-, after-, because-* and *if*-clauses, children had to select a matching picture sequence, only one of which was a correct match to the sentence they heard. They found no overall advantage for given-before-new adverbial sentences. Instead, four-year-olds were sensitive to the tendency for initial adverbial clauses to encode given information and performed best with these sentence types. In contrast, in Junge et

al.'s (2015) act-out study examining comprehension of *when*-clauses, children simply had to remember the two events and act them out (the term *when* can encode simultaneity thus either ordering of events was appropriate). To perform this task, children may have found it easiest to first act out the event they had heard labelled most frequently (the given event), followed by the new action resulting in a preference for given-before-new. Attending to the sentence structure may have been a less useful strategy in a task where there was no obvious right and wrong answer. In addition, these children were younger than those in De Ruiter et al.'s (2020) study, so it is possible that their sensitivity to the function of adverbial clauses was less well developed. Sentence production is different from sentence comprehension in involving sentence planning and articulation, in addition to drawing on knowledge of prototypical sentence structures. Integrating the syntactic and information structural properties of adverbial sentence structures and selecting the most appropriate structure for the discourse context is likely to take developmental time. Therefore, children with limited processing capacities may instead choose to first highlight the new information that they consider most worthy of mention (Narasimhan & Dimroth, 2008), resulting in an early preference for new-given information orders.

Finally, our results showed that children tended to change the order of length from LONG-SHORT to SHORT-LONG in their production of all types of sentences. As suggested by previous literature (e.g., Arnold et al., 2000), this short-before-long preference has some major advantages in utterance planning and requires less processing load. However, adults' changes in the order of clause length were less determined by the input clause length, but more by the input information order. They were most likely to change the clause length when they heard test sentences with a NEW-GIVEN and a SHORT-LONG order. For example, when they heard the test sentence "Shark is moving fast$_{[NEW, 4words]}$, when Hamster was sneezing really badly$_{[GIVEN, 6 words]}$.", they extended the short clause and shortened the long clause in their repetitions (i.e., "Shark was moving really fast$_{[NEW, 5words]}$, when Hamster was sneezing badly$_{[GIVEN, 5 words]}$."). This could be because adults tend to add more linguistic material for new elements instead of given elements (Arnold et al., 2000).

Given that this was a small-scale study, these results should be treated with some degree of caution, and future replication would be desirable to confirm these findings. Nevertheless, these preliminary results suggest that processing-based factors strongly influence young children's production of *when*-clauses. Young children show a stronger preference towards the clause order that requires less planning and processing load, potentially as a result of more limited processing capacities. However, in sentence production at least, it seems they have not yet attained an adult-like sensitivity to discourse-pragmatic factors, i.e., to place given information earlier in the adverbial clause.

Acknowledgments

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Data Availability Statement

The datasets generated and analysed during the current study are available in the Open Science Framework repository, https://osf.io/dk9gr/.

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Supplemental Materials

Table S1

Test sentences for the sentence repetition task

Condition	Sentences No.	Sentences
A	Introductory	Pig is swimming, oh he's swimming.
	1	When Pig is swimming, Little Panda is drinking very fast.
	2	When Pig is swimming, Tiny Froggy is jumping really high.
	3	When Pig is swimming, Mister Elephant is sitting so still.
B	Introductory	Mister Zebra is pushing really hard, oh he's pushing really hard.
	1	When Sheep is drawing, Mister Zebra is pushing really hard.
	2	When Cat is singing, Mister Zebra is pushing really hard.
	3	When Seal is falling, Mister Zebra is pushing really hard.
C	Introductory	Crocodile is crying so badly. Oh he's crying so badly.
	1	When Crocodile is crying so badly, Brown Bear is sleeping.
	2	When Crocodile is crying so badly, White Swan is eating.
	3	When Crocodile is crying so badly, Big Fox is sweeping.
D	Introductory	Brown Horse is running. Oh, he's running.
	1	When Donkey is talking very loudly, Brown Horse is running.
	2	When Spider is climbing really slowly, Brown Horse is running.
	3	When Kangaroo is hiding so quietly, Brown Horse is running.
E	Introductory	Miss Duck is paddling, oh she's paddling.
	1	Miss Duck is paddling, when Bunny is hopping very slowly.
	2	Miss Duck is paddling, when Dinosaur is swinging really high.
	3	Miss Duck is paddling, when Rhinoceros is spinning so fast.
F	Introductory	Mister Fish is knocking very loudly. Oh he's knocking very loudly.
	1	Mister Fish is knocking very loudly, when Snake is crawling.
	2	Mister Fish is knocking very loudly, when Dog is digging.
	3	Mister Fish is knocking very loudly, when Wolf is walking.
G	Introductory	Hamster is sneezing really badly, oh he's sneezing really badly.
	1	Bird is flying high, when Hamster is sneezing really badly.
	2	Mouse is walking fast, when Hamster is sneezing really badly.
	3	Shark is moving fast, when Hamster is sneezing really badly.
H	Introductory	Cow is sliding, oh she's sliding.

1	Blue Parrot is laughing very loudly, when Cow is sliding.
2	Tall Giraffe is turning really quickly, when Cow is sliding.
3	Little Koala is dancing so fast, when Cow is sliding.

Table S2

Significant effects and interactions in the final model of the factors influencing participants' changes of clause length (in syllables) (see 'Data Analysis' section for approach to model building)

	β	*SE(β)*	*t*	*p*
(Intercept)	-1.06	0.38	-2.74	0.007
Age group_5yr	**2.01**	**0.52**	**3.90**	**< .001**
Age group_Adult	**4.56**	**0.51**	**8.94**	**< .001**
Clause length_SHORT-LONG	0.08	0.49	0.17	0.869
Information order_NEW-GIVEN	0.45	0.51	0.88	0.379
Age group_5yr: Clause length_SHORT-LONG	**-2.75**	**0.66**	**-4.18**	**< .001**
Age group_ Adult: Clause length_SHORT-LONG	**-7.50**	**0.65**	**-11.51**	**< .001**
Age group_5yr: Information order_NEW-GIVEN	-0.63	0.67	-0.94	0.350
Age group_ Adult: Information order_NEW-GIVEN	**-2.45**	**0.66**	**-3.72**	**< .001**
Clause length_SHORT-LONG: Information order_NEW-GIVEN	-0.49	0.71	-0.69	0.489
Age group_5yr: Clause length_SHORT-LONG: Information order_NEW-GIVEN	1.64	0.94	1.74	0.081
Age group_Adult: Clause length_SHORT-LONG: Information order_NEW-GIVEN	**4.95**	**0.93**	**5.32**	**< .001**

Note. Age group = Adult vs. 5yr vs. 3yr (reference level). Clause length = SHORT-LONG vs. LONG-SHORT (reference level). Information order = NEW-GIVEN vs. GIVEN-NEW (reference level). Number of observations = 1125. Significant effects are highlighted in bold.

Table S3

Pairwise comparisons of the effect of input clause order on each age group's changes of clause order

Effect	Contrast	*β*	*SE(β)*	*z*	*p*
	3yr - 5yr	-0.12	0.53	-0.22	1.000
Clause order_MAIN-WHEN	3yr - Adult	-0.26	0.52	-0.50	1.000
	5yr - Adult	-0.14	0.33	-0.43	1.000
	3yr - 5yr	**1.19**	**0.51**	**2.35**	**0.057**
Clause order_WHEN-MAIN	**3yr - Adult**	**2.39**	**0.51**	**4.67**	**< .001**
	5yr - Adult	**1.20**	**0.35**	**3.40**	**0.002**
Age group_3yr	**MAIN-WHEN - WHEN-MAIN**	**-1.61**	**0.54**	**-3.00**	**0.003**
Age group_5yr	MAIN-WHEN - WHEN-MAIN	-0.29	0.28	-1.06	0.288
Age group_Adult	**MAIN-WHEN - WHEN-MAIN**	**1.04**	**0.26**	**4.02**	**< .001**

Note. Significant effects are highlighted in bold.

Table S4

Pairwise comparisons of the effect of input information order on each age group's changes of information order

Effect	Contrast	*β*	*SE(β)*	*z*	*p*
	3yr - 5yr	**1.39**	**0.33**	**4.21**	**< .001**
Information order_GIVEN-NEW	**3yr - Adult**	**3.64**	**0.44**	**8.30**	**< .001**
	5yr - Adult	**2.25**	**0.44**	**5.14**	**< .001**
	3yr - 5yr	0.25	0.33	0.76	1.000
Information order_NEW-GIVEN	**3yr - Adult**	**0.95**	**0.33**	**0.87**	**0.012**
	5yr - Adult	0.70	0.33	2.15	0.095
Age group_3yr	**GIVEN-NEW - NEW-GIVEN**	**0.64**	**0.27**	**2.41**	**0.016**
Age group_5yr	GIVEN-NEW - NEW-GIVEN	-0.50	0.27	-1.87	0.062
Age group_Adult	**GIVEN-NEW - NEW-GIVEN**	**2.05**	**0.40**	**-5.18**	**< .001**

Note. Significant effects are highlighted in bold.

Table S5

Pairwise comparisons of the effects of input clause length and input information order on each age group's changes of clause length (in words)

Effect	Contrast	*β*	*SE(β)*	*t*	*p*
Clause length_SHORT-LONG Information order_GIVEN-NEW	3yr - 5yr	0.01	0.29	0.05	1.000
	3yr - Adult	0.50	0.29	1.75	0.245
	5yr - Adult	0.49	0.29	1.71	0.265
Clause length_SHORT-LONG Information order_NEW-GIVEN	3yr - 5yr	-0.40	0.30	-1.36	0.524
	3yr - Adult	-0.45	0.29	-1.53	0.381
	5yr - Adult	-0.05	0.29	-0.16	1.000
Clause length_LONG-SHORT Information order_GIVEN-NEW	**3yr - 5yr**	**-1.03**	**0.29**	**-3.50**	**0.002**
	3yr - Adult	**-2.21**	**0.29**	**-7.61**	**< .001**
	5yr - Adult	**-1.18**	**0.29**	**-4.12**	**< .001**
Clause length_LONG-SHORT Information order_NEW-GIVEN	**3yr - 5yr**	**-0.91**	**0.30**	**-3.06**	**0.008**
	3yr - Adult	**-1.23**	**0.29**	**-4.18**	**< .001**
	5yr - Adult	-0.31	0.29	-1.10	0.824

Note. Significant effects are highlighted in bold.