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The influence of pragmatic function on children's comprehension of complex *because*- and *if*-sentences

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Introduction: In complex adverbial sentences, the connectives *because* and *if* can perform different pragmatic functions (e.g. Content, Speech-Act), although this is often overlooked in studies investigating children's acquisition of these connectives. In this study, we investigated whether pragmatic variation is responsible for some of the difficulty young children have in understanding *because*- and *if*-sentences and tested the extent to which patterns of acquisition are related to the cognitive complexity or input frequency of the different pragmatic types.

Methods: Ninety-two children (aged 3–5; $F = 39$) and 20 adults ($F = 12$) took part in a forced-choice picture task where they had to identify correct pictures after hearing Content and Speech-Act *because*- and *if*-sentences.

Results: Results showed that children were most accurate on the sentence type where cognitive simplicity and input frequency converge (*If* Content), but this pattern was largely driven by the girls in the study. For response times, children were fastest with the least cognitively complex sentence types. However, for *because* Speech-Act sentences, there was an inverse relationship between response time and input frequency.

Discussion: Taken together, these findings suggest that neither account (cognitive complexity or input frequency) can fully explain the findings. Instead, we suggest that the relative contributions of both factors are best understood in terms of the relevance of these utterances to children and the precise contexts in which children hear these utterances produced.

KEYWORDS
language acquisition, complex adverbial sentences, pragmatic function, *because*-sentences, *if*-sentences

1 Introduction

Once children move beyond the early stages of language development, they start to produce more complex utterances using connectives to express the relationship between two clauses. Apart from '*and/then/but*', the early connectives used by English-speaking children are temporal (e.g. *after, before*), causal (e.g. *because*) and conditional (*if*) (e.g. Braunwald, 1985; Diessel, 2004). The comprehension and production of these connectives present cognitive and communicative challenges. Cognitively, children need to have a grasp of concepts such as temporality, causality and conditionality. But connectives are also used meta-communicatively to justify illocutionary acts in the main clause of the utterance (Don't do that because you'll break it; You can have a biscuit if you're ready for pudding now). To further complicate matters, the different connective types are used to communicate these different functions with differing frequencies in the language children hear.

In this paper, we focus on children's comprehension of the connectives *because* and *if* as a lens through which to ascertain the effects of input frequency and cognitive complexity on acquisition. In addition, since children hear and interpret these sentences within interactive contexts to convey very specific meanings, we consider how their precise patterns of use in interaction might add an important additional factor in the study of their acquisition when interpreting our results.

Several studies have shown that comprehension of complex sentences containing the adverbial connectives *because* and *if* is problematic for young children. For example, Emerson and Gekoski (1980) concluded that children do not fully understand these connectives before about age ten. However, children produce these connectives competently around or before age three (Bloom et al., 1980; Braunwald, 1985; De Ruiter et al., 2021; Diessel, 2004; McCabe et al., 1983; Reilly, 1986). Moreover, the speech of children as young as 2 years old has been shown to evidence some understanding of hypotheticality, contingency, inference and habituality, which are argued to be required for comprehension of *if* (see Bowerman, 1986 for review and analysis) and experimental studies have shown that toddlers and pre-schoolers can use causal reasoning (e.g. Gopnik, 2012 provides a review). Thus, children appear to possess a relatively robust understanding of how to use these connectives, as well as a general comprehension of the underlying concepts they express but nevertheless continue to show difficulties in comprehension.

Conclusions about children's difficulty with these connectives have primarily been based on children's understanding of what Sweetser (1990) calls Content sentences (e.g. Amidon, 1976; De Ruiter et al., 2020, 2018; Emerson, 1979, 1980; Emerson and Gekoski, 1980; French, 1988; Johnston and Welsh, 2000). According to Sweetser (1990) model, Content sentences with *because* express "real-world" causes (e.g. Your shoes are wet because you stepped in a puddle) whereas Content sentences with *if* express real-world sufficient conditional relationships (e.g. Your shoes will get wet if you step in a puddle, De Ruiter et al., 2021). However, there are two further pragmatic types of causal and conditional sentences, which are largely overlooked in experimental research on young children's acquisition of *because* and *if*. Sweetser (1990) calls these types Speech-Act and Epistemic. In *because* Speech-Act sentences, the subordinate clause (sub-clause) explains a speech (illocutionary) act[1] (e.g. Don't step in puddles because you are getting your shoes wet). In *if* Speech-Act sentences, it defines the conditions relating to the performance of the illocutionary act (e.g. Don't get your shoes wet if you insist on stepping in puddles); in Epistemic sentences, the sub-clause provides evidence for a conclusion expressed in the main clause (e.g. You were stepping in puddles because/if your shoes are wet).[2]

The lack of information about children's comprehension of these other pragmatic types means we are left with an incomplete understanding of children's acquisition of these connectives and the factors that may influence the process. However, the different pragmatic types have been argued to vary in terms of the cognitive skills required to interpret them (e.g. Zufferey, 2010, see below), thus their cognitive complexity could be a factor affecting their ease of acquisition. Moreover, the frequency with which children hear the different connectives used to perform different functions in naturalistic speech also varies (De Ruiter et al., 2021, see below). Since usage-based models of language acquisition posit a critical role for input frequency in the acquisition of form-meaning mappings (see Ambridge et al., 2015 for an overview), an investigation of the role of input frequency in the acquisition of these connectives to convey different pragmatic meanings is needed. Indeed, previous literature (e.g. Sanders, 2005) has called for a comparison of input frequency and cognitive complexity in order to better understand children's acquisition of these connectives.

1.1 Cognitive complexity of the different pragmatic types of *because* and *if*

In Content sentences, the form-function mapping is to a real-world state or event (The bell is ringing because/if it's time for school*)* with *because*-clauses providing a real-world cause for the state/event conveyed in the main clause, and *if*-clauses describing the required conditions for the state/event. Thus, Content sentences function to explain causes or required conditions (Kyratzis et al., 1990; Sweetser, 1990). According to Zufferey (2010), the processing of Content sentences involves the "retrieval of the utterance's basic explicature" (p. 106), that is, the words spoken convey a very direct and explicit relation with the real world. In contrast, in Speech-Act sentences (Don't jump on that because you'll break it, Don't break it if you are going to keep jumping), the sub-clause explains or justifies an illocutionary act or provides the conditions for it, rather than explaining how a state/event occurred or could occur (Kyratzis et al., 1990; Sweetser, 1990). As such, Zufferey (2010) argues that understanding Speech-Act sentences requires the construction of some form of metarepresentation to map to the speaker's intention in producing the utterance, rendering them more cognitively complex than Content sentences. More specifically, Zufferey (2010) argues that Speech-Act sentences are more difficult for children than Content because they require meta-communicative skills i.e. an understanding that the sub-clause explains, justifies or provides the conditions for the main clause illocutionary act (*don't jump on that/don't break it*) in interaction.

In terms of children's general cognitive development, there is ample evidence that pre-linguistic infants are sensitive to causality. They are able to distinguish between causal and non-causal events (e.g. Durrant et al., 2021; Leslie, 1982, 1984; Oakes and Cohen,

1 Following Lemen et al. (2021), although other authors (e.g. Sweetser, 1990) refer to the main clause of Speech-Act sentences (e.g. *Don't step in puddles* in the example above) as "speech acts," we use the term "illocutionary acts" for this, reserving the label "Speech-Act" for the pragmatic category.

2 We do not discuss the Epistemic category further. Although some previous studies have found that children are more accurate with Content causal sentences than Epistemic causal sentences (Corrigan, 1975; Zufferey et al., 2015) suggesting that children have some sensitivity to these pragmatic differences, Epistemic is considered the most cognitively complex pragmatic type (Zufferey, 2010) and is the least frequent in caregiver speech with both *because* and *if* (De Ruiter et al., 2021). Thus, Epistemic does not serve as a helpful tool in evaluating the effects of input frequency in comparison to cognitive complexity with *because* and *if*.

1990), and by 3 years of age, children demonstrate an above-chance understanding that causes must precede their effects (the temporal priority principle), though this improves further with age (Rankin and McCormack, 2013). This suggests that by the time children begin to acquire connectives that encode relations between cause and effect (of the type seen in Content sentences), the basic underlying concepts are already in place; the challenge is to learn how to map these elements into language.

At the same time, children show developing socio-cognitive skills, for example 1-year-olds can understand others' intentions in communicative contexts (e.g. Camaioni et al., 2004), along with a growing sensitivity to the pragmatic factors governing language use. For example, whilst 2-year-old children show Level 1 perspective-taking skills (understanding that others can have different viewpoints than themselves) and display pragmatic inferencing skills in responding to interlocutor requests (e.g. Moll and Tomasello, 2006), only during the later preschool years do children begin to use referential language appropriately as a function of the knowledge state of their interlocutor (e.g. Matthews et al., 2006). Other aspects of pragmatic understanding take longer, for example with children's grasp of non-literal language in order to interpret the intended meaning of the speaker continuing to develop to age five and above (e.g. indirect requests, Bernicot et al., 2007, inferences, Currie and Cain, 2015). Similarly, children's ability to provide justifications during interactions with others is evident in nascent form from around 2/3 years of age, but shows further development in terms of its relevance and marked use of causal explanations by 5 years of age (e.g. Veneziano, 2001; Kyratzis et al., 2010). These kinds of socio-cognitive and pragmatic skills are likely to relate to the ability to create metarepresentations of the kind that may underpin Speech-Act sentences. Thus, although children have some grasp of the concepts underpinning both Content and Speech-Act sentences by 3 years of age, the overall developmental picture suggests that Content relations may be more advanced than pragmatic understanding in relation to language use.

1.2 Input of the different pragmatic types

There is evidence that both Content and Speech-Act sentences are produced with *because* and *if* by caregivers in their speech to young English-speaking children, although not in equal distribution. De Ruiter et al. (2021) analyzed the speech of two preschool-aged children (aged between 2;6–4;11) and their mothers (primary caregivers) using densely collected corpora and an additional 12 children (aged between 2;10–3;6, Rowland and Theakston, 2009; Theakston and Rowland, 2009). They found that, in the dense datasets, with *because* 46 and 73% of the mothers' utterances were coded as Speech-Act compared to 37 and 19% as Content, but Content was the most frequently produced type with *if* (79 and 80%) with only 16 and 18% as Speech-Act; in the combined data from 14 children, on average 63% (SD = 9.2) of *because* utterances were Speech-Act compared to 22% (SD = 6.9) as Content, whereas 69% (SD = 5.8) of *if*-utterances were Content compared to 28% (SD = 7.5) as Speech-Act. Epistemic was infrequent for both connectives. Thus, children hear a higher proportion of *because* Speech-Act sentences than *because* Content sentences, but a higher proportion of *if* Content sentences than *if* Speech-Act sentences. This finding for *because* is anecdotally supported by Kyratzis et al. (1990) who note that "a preliminary analysis of the *adults*' uses of causals in this corpus revealed that a vast majority were also Speech Act-Level causals" (p. 210). Furthermore, more general studies of adult usage of *because* (e.g. Diessel and Hetterle, 2011; Ford, 1993) suggest that in many languages *because*-clauses regularly function to provide explanations for statements, thus seeming to align with Sweetser (1990) Speech-Act.

Based on a cognitive complexity account, we would expect Content to be easier than Speech-Act for both *because* and *if* sentences. However, if input-frequency is the important factor in comprehension, based on input patterns for specific form-function mappings, we would expect Speech-Act to be the easiest pragmatic type for *because* and Content to be the easiest pragmatic type for *if*. A final possibility is that the two factors interact. If both cognitive complexity and input frequency provide separate cues to meaning, *if*-Content sentences could have a particular advantage as they are both cognitively simpler and frequent in the input. *Because*-Content sentences (cognitively simpler but infrequent) and *because*-Speech-Act (frequent but cognitively more complex) have competing cues to meaning. Finally, *if*-Speech-Act sentences may show a particular disadvantage as they are both more cognitively complex and infrequent.

How might these observations help explain children's apparent difficulties with *because* and *if* Content sentences in experimental studies? For *because*, input frequency could help explain the observed gap between production and comprehension as *because*-Content sentences are relatively lower frequency in the input (see De Ruiter et al., 2021; Kyratzis et al., 1990 for related arguments). For *if*, although the typically-tested Content are the most frequent type in the input, approximately a third of the *if*-sentences children hear are non-Content (De Ruiter et al., 2021). As such, one possibility is that noise in the form-function mappings in the input makes these connectives more complicated (see e.g. Slobin, 1982) for children than connectives (such as *before*) which do not express different pragmatic meanings to the same extent (see De Ruiter et al., 2021; Lemen et al., 2021 for related arguments). From this perspective, a frequency account may be more helpful in explaining children's difficulty with Content sentences than a cognitive account. However, despite these theoretical possibilities, very little is known about whether English-speaking children's comprehension of *because* and *if* is impacted by pragmatic variation, let alone the extent to which it is influenced by input or cognitive complexity. This is the focus of the present study.

1.3 Aims

Corpus data (e.g. De Ruiter et al., 2021; Evers-Vermeul and Sanders, 2011; Kyratzis et al., 1990) have demonstrated that pragmatic variation occurs with the connectives *because* and *if* and the mapping of particular connectives to particular pragmatic meanings (Content vs. Speech-Act) varies in terms of their frequency of occurrence in the input children hear. To tease apart the possible effects of cognitive complexity and input frequency on children's comprehension, we use two connective types—*because* and *if*—that have opposite form-meaning mappings in terms of their frequency of use. *Because* appears most often in Speech-Act sentences, while *if* appears more frequently in Content sentences. The inclusion of two age groups allows us to examine whether patterns change across development. By school-age, children are moving toward more consistently complex play with their peers (Howes and Matheson, 1992) so might be less troubled by the meta-communicative demands of the Speech-Act relationship compared to when they are first acquiring these skills as toddlers (Zufferey, 2010 relates acquisition of early meta-communicative skills and production of Speech-Act sentences around the age of two-and-a-half). Additionally, as we expect higher-frequency forms to be learned earlier than low-frequency forms (Ambridge et al., 2015), younger children might have more difficulty understanding low-frequency forms than older children, who have more linguistic experience. Therefore, by comparing comprehension of the most frequent pragmatic types for *because* and *if* at different ages we will gain a better idea of the overall impact, generalizability and longevity of these factors on children's acquisition of these connectives.

Given this framework, the most direct predictions from these accounts are:

- If cognitive complexity has the strongest influence on comprehension, Content will be easiest for both connectives.
- If input frequency has the strongest influence on comprehension, Speech-Act will be easiest for *because* and Content easiest for *if*.

However, it is also possible that the two factors will interact, see above (e.g. Ambridge et al., 2015; De Ruiter et al., 2018), and their influence (either in isolation or their interaction) could change with age. As such, this study has two main aims: (i) to determine whether input frequency and/or cognitive complexity impact(s) children's comprehension of *because*- and *if*-sentences expressing different pragmatic relationships, and (ii) to explore the extent to which these factors interact and/or change with children's development.

As some studies have reported relations between children's general language and cognitive skills and their overall performance on tasks involving complex sentences (e.g. Blything et al., 2015; Blything and Cain, 2016; De Ruiter et al., 2018, 2020), a series of child-level factors were measured and included as controls to ensure that these potential effects did not mask the effects of the variables of interest. In addition, some studies have reported differences in boys' and girls' functional use of connectives (e.g. Kyratzis et al., 2010). Although we made no a priori predictions about gender and it was not a primary focus of the study, we included gender as an exploratory factor in our analyses.

2 Materials and methods

2.1 Participants

Ninety-three monolingual English-speaking children without known language or developmental delays were recruited [based on power analysis (R Core Team, 2018) indicating that 90 children would give adequate power to find a small effect size[3]]. Children were tested at their school/nursery or at the Child Study Center at the University of Manchester. Forty-two children were aged 3;00–4;01 [*M* = 3;07, SD = 3.6, Female (18); hereafter referred to as 3-year-olds] and 50 were between 4;05–5;07 [*M* = 5;00; SD = 3.7; Female (21); hereafter referred to as 5-year-olds]. One additional child was tested but excluded because they were out of the age range of the two groups (4;04:18). Twenty monolingual, English-speaking adults [Female (12)] were also tested at the University of Manchester to ensure that the test stimuli unambiguously matched with the target sentences.

2.2 Ethical approval

This study was approved by the University of Manchester's University Research Ethics Committee, Ref: 2018-3229-5161. In line with the approved ethics procedure, written consent was provided by caregivers, headteachers/nursery managers and adult participants; children provided further verbal assent prior to all tasks. If any participant did not want to complete/start any task, the task was ended/not begun.

2.3 Connectives comprehension task

2.3.1 The task

Children heard a series of 20 connective sentences, 10 containing *because* and 10 containing *if*. With each connective, five sentences encoded a Content meaning and five a Speech-Act meaning. Accompanying each sentence were two pictures, the target and a distractor. The participants' task was to select the matching picture for the sentence. Both target and distractor pictures contained elements that mapped onto the main and sub-clause of the test sentence (in the example below, jumping and bed). However, only the target image mapped onto the meaning conveyed by the connective (causal or conditional relation between the two parts of the sentence). This meant that choice of the correct image was dependent on understanding something of the connective meaning, rather than simply mapping the key elements of the two clauses onto elements of the image. Figure 1 shows the sentences and associated target and distractor images for the "breaking the bed" context. All images show a character jumping and a bed. For the *Because* sentences, both images show a broken bed reflecting the causal meaning encoded by the connective. For the *If* sentences, in both images the bed is shown unbroken, but with an indication that it may be about to break (the legs are marked) reflecting the conditional meaning encoded by the connective. In the distractor images, the action of jumping is to one side of the bed, whereas in the target images the character is jumping on the bed.

3 Note, the power analysis was conducted assuming a frequentist approach to analysis. Subsequently, to reflect developments in the field, a Bayesian approach to analysis was adopted—see Section 3.2 for details and justification.

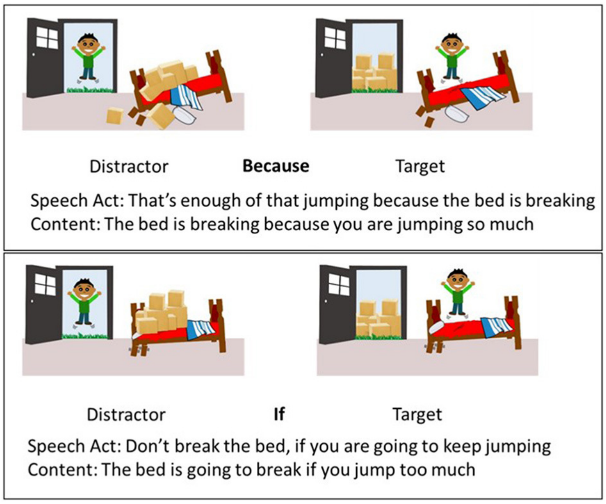

FIGURE 1
Sample target and distractor images associated with the "breaking the bed" event.

2.3.2 Sentence stimuli

Forty test sentences were created to describe 10 distinct event types (see Supplementary Appendix A for details). There were four sentence types created to map onto each event, to comprise a "sentence set"; (i.e., *Because* Content, *Because* Speech-Act, *If* Content and *If* Speech-Act). Sentence length was controlled across each sentence pair within a set, so that the two sentences for each connective were equal in length. Sentence length for all pairs ranged from 10 to 14 words ($M = 11.8$, SD = 1.3).

Three warm up items and four fillers were created. The first warm up item was a simple sentence. The following two were complex sentences connected by temporal connectives, so that children became familiar with sentence length/complex structure without hearing *because* or *if*. All fillers were simple sentences. The audio for all items was recorded in Audacity v2.3.0 (Audacity Team, 2018) by a native speaker of British English using natural prosody to reflect natural input patterns as closely as possible.

The 40 test sentences were split across two stimuli lists (see Supplementary Appendix A), each containing 20 sentences consisting of five of each sub-type of test sentence, plus all warm ups and fillers. Within each list, sentences were presented in five blocks of four sentences, separated by a filler.

2.3.3 Images

The images for *Because* Content and *Because* Speech-Act within a set were the same, reflecting events that had already taken place, and the images for *If* Content and *If* Speech-Act within a set were the same, reflecting events just about to take place (see Figure 1). For any given semantic event, the images for causal *because* and conditional *if* events were similar, but differed in relation to the critical difference in meaning encoded by the connective [e.g. the bed was shown as already broken (*because*), or on the verge of becoming broken (*if*)]. The target image reflected the causal or conditional relationship expressed in the sentence; the distractor image reflected the same semantic elements, but without the causal or conditional relationship connecting them.

2.3.4 Procedure

Stimuli were presented to participants on an ASUS Zenbook UX330U, using PsychoPy (Peirce, 2009) v1.84.4. The laptop was converted to a touchscreen using an AirBar (https://air.bar/). For children, a piece of white cardboard with cut-outs of two red hands was placed over the keyboard of the laptop and children were asked to keep their hands on the red hands until the end of the sentences. Participants were told they would see two pictures on the screen and that, in both pictures, there will be a child. They were then told that they would also hear the mother of the child in the pictures say a sentence and the participant's role was to point to the picture that matched with what the mother said.

Participants were randomly allocated to one of eight ordered lists, with distribution across lists being as equal as possible. After the warm up items, the main task began. In each trial, after hearing the sentence, participants indicated their choice by touching the screen. Image location was counterbalanced (top/bottom) so that, within each list, half of the correct answers for each pragmatic type and each connective appeared on the top. Accuracy and response time (RT) data were recorded. Subsequent trials proceeded automatically after registering the participant's response.

2.4 Executive function and language tasks

In this study, we were interested in the group-level effects of cognitive complexity and input frequency on children's comprehension of *because* and *if*. However, as previous studies of children's complex sentence comprehension and production (e.g. Blything et al., 2015; Blything and Cain, 2016; De Ruiter et al., 2018, 2020) suggest that child-level factors can affect performance, we followed De Ruiter et al. (2018) approach in controlling for child-level factors which could possibly mask the effects of our variables of interest. In addition to the main comprehension task, children took part in additional tasks measuring: memory (digit span, adapted from Wechsler, 2014), linguistic skill [Linguistic Concepts and Sentence Structure sub-tests from the Clinical Evaluation of Language Fundamentals®-Preschool-2 (CELF), Wiig et al., 2004], cognitive flexibility [Dimensional Change Card Sort (DCCS) task, Zelazo, 2006] and understanding of Speech-Act causality (see Supplementary Appendix B for full details). As in De Ruiter et al. (2018), where scores from these tasks correlated with children's accuracy and RTs, these were entered into the models as controls and only retained when a model containing them was a better fit to the data. Adults only performed the main comprehension task. All participants completed all tasks in one session, lasting about 30–45 min for children and 10 min for adults. Children were offered a short break half-way through the session.

3 Results

3.1 Exclusions

Prior to analyses, a number of exclusion criteria were applied to the data. These were: incorrectly answering at least three of five of the simple sentences from the warm up and fillers; responses prior to the end of the audio stimuli, and; failure to pass (at least 50%) the Speech-Act causality task (see Supplementary Appendix C for details). After exclusion criteria were applied (138 responses), 2,082 responses remained (3-year-olds: 699 from 36 participants; 5-year-olds: 983 from 50 participants; Adults: 400 from 20 participants).

3.2 Analysis strategy

Analysis was done using R software (R Core Team, 2018) v3.5.1 Feather Spray. First, correlations with both accuracy and RT were calculated (BayesMed package, Nuijten et al., 2015) for the scores from the executive function and language tasks (see Supplementary Appendix D for raw scores and correlations between scores on these tasks and accuracy/RT). Scores correlating with accuracy (digit span forwards and backwards only) were later tested to see if they improved the fit of the accuracy model for the main task (no scores from the additional tasks correlated with RT).

For the main task, Bayesian linear mixed models were used (Granlund et al., 2019; Nicenboim et al., 2018). Models were run using the *brms* package (Bürkner, 2018), which concurrently runs RStan (Stan Development Team, 2018, 2020) using the default (uninformative) priors for all models. Following Granlund et al. (2019) and Engelmann et al. (2019), models were run with maximal random effects structure, as this reduces Type I statistical errors (Barr et al., 2014). To test for the effects of input frequency and cognitive complexity, model predictors were the within-subject factors (Pragmatic Type: Content, Speech-Act; Connective: *Because*, *If*) with the addition of one between-subject factor for children to test for any change in these effects over development (Age: Three, Five). The models included all predictors (centered) and all two-way and three-way interactions. To ascertain the extent to which our factors of interest (input frequency and cognitive complexity) were able to account for the results, it was necessary to also include two additional factors (Trial Order, Gender) which could potentially impact on performance, so were entered as control and exploratory factors respectively. These additional factors were tested individually against the maximal model using LOO cross-validation method in *brms* (Bürkner, 2018) and retained when they resulted in a better model fit. The same process was followed for the additional executive function and language control tasks that showed significant correlations with accuracy. These variables were included to identify the effects of input frequency and cognitive complexity when taking other child-level factors into account.

As the adults did not do the additional executive function and language tasks, the adult and child models were run separately. To ensure the maximal structure was best suited to each group and task, the children's accuracy model had an additional random slope by participant for location of the image (top or bottom), both the children's and adults' RT models had an additional random slope by participants for item order relative to its semantic pair in a list and the adults' RT had an additional intercept for keywords (e.g. Water spilling), as these were found to improve the fit of the respective models when tested against a null structure. All models had random intercepts for item and participant and random slopes for the interaction between Pragmatic Type and Connective for participants.

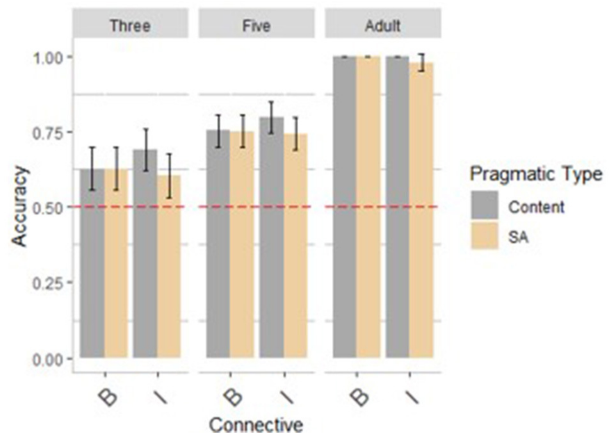

FIGURE 2
Accuracy by age, connective (B = because; I = if) and pragmatic type (Content, SA = Speech-Act).

For all Bayesian models, mean, upper (UCI) and lower (LCI) 95% credible intervals and Probability (*P*) are reported. Evidence for an effect is interpreted using the *P* in the same way as Engelmann et al. (2019). *P* values were calculated from the models using a function script in R (R Core Team, 2018) similar to the ones used in Engelmann et al. (2019) and Granlund et al. (2019):

- No evidence: *P* values at or around 0.5.
- Weak evidence: *P* values starting at ~0.85 and up to 0.9499.
- Strong evidence: *P* values at 0.95 or above and/or credible intervals that do not cross zero.

3.3 Accuracy

The 3-year-olds' mean proportional accuracy was 0.63 (SD = 0.48); the 5-year-olds' 0.76 (SD = 0.43) and the adults' 0.995 (SD = 0.07) (see Figure 2).

3.3.1 Children's accuracy models

Table 1 shows the output for the children's maximal model. This shows only a strong effect of age (5-year-olds were more accurate than 3-year-olds), but no effects relating to either input frequency or cognitive complexity (as would be indicated by effects of, or interactions between Pragmatic Type and Connective).

To ascertain whether our results may reflect effects of other factors, we then examined the role of Trial Order (a control factor) and Gender (an exploratory factor). While the addition of Trial

TABLE 1 Children's accuracy model.

Comparison	Mean	Lower	Upper	$P(b < 0)\|\|P(b > 0)$
Intercept	1.4452	0.8699	2.0371	1.0000
Age	**−0.7359**	**−1.3656**	**−0.1696**	**0.9940**
PragmaticType	−0.0362	−0.7561	0.7189	0.5422
Connective	0.2570	−0.5212	1.0067	0.7445
PragmaticType.Connective	−0.2950	−1.3974	0.8152	0.7100
Age.PragmaticType	−0.1205	−0.7950	0.5824	0.6370
Age.Connective	−0.0653	−0.7811	0.6561	0.5732
Age.PragmaticType.Connective	0.1553	−0.8522	1.1366	0.6200

Bold indicates strong or weak evidence for an effect.

Order did not improve the model, there was some evidence that Gender did predict accuracy. That is, using the LOO function in *brms* (Bürkner, 2018), the model with Gender appeared to be better than the model without (elpd_diff = −1.0), but the standard error was bigger than the elpd_difference (SE = 1.2) so we cannot conclude either way if the model with Gender is a better fit. Running a summary of the model with a main effect of Gender, however, indicated Gender did predict accuracy (*M*: −0.3337, LCI: −0.7564, UCI: 0.0817, *P* = 0.9445) and, specifically, that the boys (coded as Males in the dataset) performed worse than girls, overall.

Although we made no explicit predictions about the role of Gender in the comprehension of causal and conditional connectives, we included Gender as an exploratory factor given that some previous studies have suggested it may play a role in language acquisition in general, and in the acquisition of complex language, and its inclusion improved model fit. For exploratory purposes we included the two- and three-way interactions between Gender and the main predictors from the study design (Age, Pragmatic Type and Connective) in the maximal model (see Table 2).

This shows:

- Strong evidence of effects of Connective (higher accuracy for *If*), and two-way interactions between Gender and Connective and Gender and Age;
- Weaker evidence of an interaction between Pragmatic Type and Connective and a three-way interaction of Gender, Pragmatic Type and Connective.

Thus, it appears that the inclusion of Gender in the model reveals effects of our factors of interest – input frequency and cognitive complexity – but these effects vary by Gender. In addition, the previously observed effect of Age also seems to vary by Gender. To explore the Gender by Age interaction, the main dataset was subsetted by Gender and models were run for both the girls' and boys' datasets. While the boys' model showed a main effect of Age (*M*: −1.2865, LCI: −2.0653, UCI: −0.5427, *P* = 0.9995), showing that 3-year-old boys performed worse than 5-year-old boys, there was no evidence of a main effect of Age in the girls' model (*M*: −0.2590, LCI: −1.0601, UCI: 0.5652, *P* = 0.7375).

To explore the three-way-interaction between Connective, Pragmatic Type and Gender without subsetting the data any further, a contrast was run using emmeans (Lenth, 2019). Here, strength for an effect is shown via 95% Highest Posterior Density Intervals (HPDs). These are credible intervals which show "the distribution by specifying an interval that spans most of the distribution, say 95% of it, such that every point inside the interval has higher credibility than any point outside the interval" (Kruschke, 2015, p. 87). The contrast showed that although the upper and lower HPDs for all comparisons cross zero, it only crossed marginally for the girls' *If* Content-Speech-Act contrast and Content *Because–If* contrast (see Table 3 and Figure 3). This provides some weak evidence that girls were best with *If* Content, while there were no differences in accuracy for any other sentence types for either group.

In summary, when Gender was not considered, only Age predicted accuracy, we found no effects of either input frequency or cognitive complexity. However, an exploratory analysis with the inclusion of Gender in the model (see Table 4 for percentage correct by Gender, Age, Connective and Pragmatic Type) shows:

- While 3-year-old boys perform worse than 5-year-old boys, 3-year-old girls' performance is similar to 5-year-old girls.
- There was weak evidence that girls were most accurate with *If* Content sentences (implying a role for input frequency and/or cognitive complexity), while there was no evidence that the boys' accuracy differed for any sentence type.

3.3.2 Children's accuracy compared to chance

To further examine any potential effects of input frequency and/or cognitive complexity in relation to Gender, Bayesian *t*-tests (BayesFactor package, Morey and Rouder, 2014) compared accuracy on each sentence type to chance (see Table 4). The evidence for Bayesian correlations is interpreted via a Bayes Factor (Jeffreys, 1961 as cited in Wetzels et al., 2011, p. 293 for an adapted table).

These results reinforce the difference between 3-year-old boys and girls: while there is only anecdotal evidence that 3-year-old boys perform above chance on one sentence type (*If* Content), there is decisive or (very) strong evidence that all other groups

TABLE 2 Children's accuracy model including gender.

Comparison	Mean	Lower	Upper	$P(b < 0)\|\|P(b > 0)$
Intercept	1.2331	0.5055	1.9891	1.0000
Gender	**0.4140**	**−0.3896**	**1.2147**	**0.8555**
Age	−0.0929	−0.9715	0.8142	0.5915
PragmaticType	0.0619	−0.8196	0.9785	0.5515
Connective	**0.8367**	**−0.1205**	**1.8085**	**0.9595**
PragmaticType.Connective	**−0.7756**	**−2.0631**	**0.4715**	**0.8845**
Age.PragmaticType	−0.1488	−1.0581	0.7508	0.6208
Age.Connective	−0.3654	−1.3500	0.6122	0.7732
Gender.PragmaticType	−0.1885	−1.0524	0.6908	0.6540
Gender.Connective	**−0.9802**	**−1.8527**	**−0.1055**	**0.9870**
Gender.Age	**−1.1188**	**−2.2936**	**0.0457**	**0.9705**
Age.PragmaticType.Connective	0.1800	−0.8769	1.2484	0.6302
Gender.Age.Connective	0.4999	−0.5365	1.5498	0.8292
Gender.Age.PragmaticType	0.0236	−1.0261	1.0688	0.5270
Gender.PragmaticType.Connective	**0.7985**	**−0.2253**	**1.8451**	**0.9400**

Bold indicates strong or weak evidence for an effect.

TABLE 3 Contrasts of gender, pragmatic type and connective in children's accuracy model.

Group	Contrast	Estimate	Lower HPD	Upper HPD
Girls	Because Content–SA	0.0195	−0.755	0.770
Girls	**If Content–SA**	**0.6918**	**−0.119**	**1.549**
Boys	Because Content–SA	0.1913	−0.530	0.947
Boys	If Content–SA	0.0765	−0.647	0.853
Girls	**Content Because–If**	**−0.6684**	**−1.530**	**0.149**
Girls	Speech-Act Because–If	0.0298	−0.827	0.823
Boys	Content Because–If	0.0748	−0.663	0.888
Boys	Speech-Act Because–If	−0.0354	−0.863	0.714

Bold indicates strong or weak evidence for an effect.

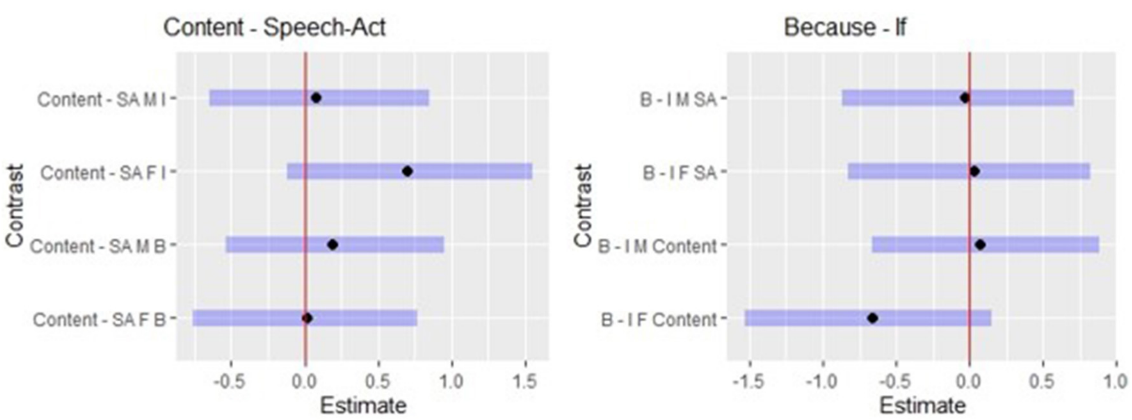

FIGURE 3
Plots showing contrasts for Content and Speech-Act (SA) for boys (M) and girls (F) by connective (B, I) **(left)** and between because (B) and if (I) for boys (M) and girls (F) by pragmatic type (Content, SA = Speech-Act).

TABLE 4 Bayes factor *t*-test output and interpretation (based on Wetzels et al., 2011) (Bayes Factors >100 rounded to nearest integer).

Group	% Correct	Bayes factor	Interpretation of evidence
3 Males Because Content	57	0.56	Anecdotal for H_O
3 Males Because SA	56	0.44	Anecdotal for H_O
3 Males If Content	59	1.03	Anecdotal for H_A
3 Males If SA	56	0.50	Anecdotal for H_O
3 Females Because Content	69	**63.50**	**Very strong for H_A**
3 Females Because SA	70	**117**	**Decisive for H_A**
3 Females If Content	79	**110,907**	**Decisive for H_A**
3 Females If SA	66	**11.03**	**Strong for H_A**
5 Males Because Content	77	**514,606,386**	**Decisive for H_A**
5 Males Because SA	77	**337,891,374**	**Decisive for H_A**
5 Males If Content	77	**369,544,841**	**Decisive for H_A**
5 Males If SA	74	**4,781,388**	**Decisive for H_A**
5 Females Because Content	72	**6,700**	**Decisive for H_A**
5 Females Because SA	72	**4,105**	**Decisive for H_A**
5 Females If Content	84	**7,833,062,997**	**Decisive for H_A**
5 Females If SA	75	**39,701**	**Decisive for H_A**

Bold indicates strong or weak evidence for an effect.

perform above chance on all sentence types. It also provides more support for the finding that, while girls' performance is highest on *If* Content (implying a role for input frequency and/or cognitive complexity), the boys' performance is more stable across all sentence types.

3.3.3 Adults' accuracy

As adults performed at ceiling (only a total of two items were answered incorrectly in the adults' data), none of the fixed effects were predictors of the adults' accuracy.

3.4 Response time (RT)

RT analyses include only correct answers (1,191 for the children; 398 for the adults). Figure 4 shows the log-transformed RT data for the three age groups. The average RT for 3-year-olds was 3.7 s (SD = 2.8); for 5-year-olds 2.9 s (SD = 3.2) and for adults, 1.6 s (SD = 0.8).

3.4.1 Children's RT models

While our exploratory factor of Gender did not improve the children's RT model fit, our control variable of Trial Order did and was included in the model (see Table 5). This model shows strong evidence of a main effect of Age (5-year-olds were faster) and weak evidence of main effect of Pragmatic Type (children were faster with Content) and a two-way interaction for Connective and Pragmatic Type, suggesting an impact of input frequency and/or cognitive complexity.

To investigate the two-way interaction between Pragmatic Type and Connective, the dataset was split by connective and maximal models were run for the two datasets. While there was no reliable evidence for Pragmatic Type in the *If* data (*M*: −0.0260, LCI: −0.1668, UCI: 0.1206, $P = 0.6370$), the *Because* data showed weak evidence that children were faster with Content (*M*: 0.0968, LCI: −0.045, UCI: 0.2346, $P = 0.9092$). To determine how *Because* Content and Speech-Act compared to *If* Content and Speech-Act respectively, the main dataset was then subsetted by Pragmatic Type and models were run. There was no evidence of a main effect of Connective in the Content model (*M*: 0.0499, LCI: −0.1155, UCI: 0.2127, $P = 0.7240$), but the Speech-Act model showed weak evidence that children were faster with *If* (*M*: −0.0732, LCI: −0.1966, UCI: 0.057, $P = 0.8765$). Thus, we have weak evidence that children were slower on *Because* Speech-Act compared to both *If* Speech-Act and *Because* Content, but that there were no differences between the two *If* sentences or the two Content sentences.

3.4.2 Adults' RT models

Like the children, for adults, Trial Order, but not Gender, improved the RT model (see Table 6). This model shows weak evidence that adults responded more quickly to Content sentences.

In summary, there was some evidence that both adults and children were faster at Content, but that children were slowest at *Because* Speech-Act, specifically.

4 Discussion

This study aimed to provide insight into the role of input frequency and cognitive complexity on children's acquisition of the different pragmatic relationships expressed by the connectives *because* and *if* (as proposed by Sweetser, 1990). From a cognitive complexity perspective, Content sentences should be easier than Speech-Act, but based on input frequency, Speech-Act should be the easiest for *because* and Content the easiest for *if.* To test these predictions, this study explored children's ability (via accuracy and RT data) to match *because*- and *if*-sentences expressing different pragmatic relationships (Content, Speech-Act) to pictures. We also included Gender as an exploratory factor given its apparent role in some aspects of language development in general and in relation to complex sentences, but had no a priori predictions regarding its likely effects. Child-level factors (e.g. language ability, cognitive skills) were included where we found correlations between these skills and performance on our task to control for their possible influence in order to better identify the effects of our factors of interest.

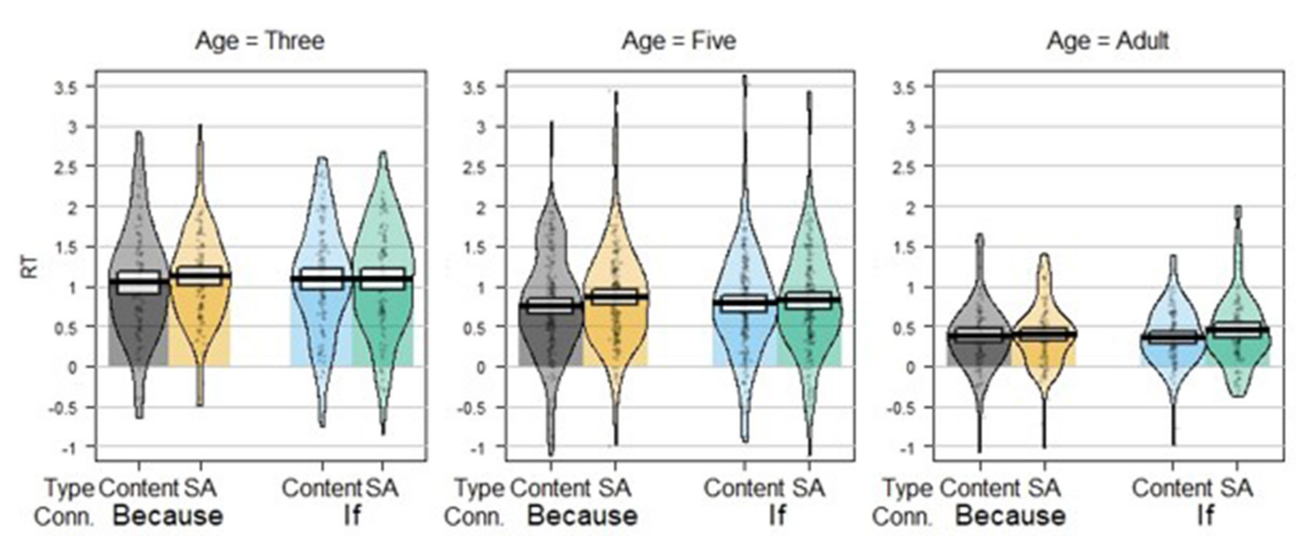

FIGURE 4
Pirate plot showing RT patterns (log-transformed) for each age group by pragmatic type (Content, SA = Speech-Act) and connective.

TABLE 5 Children's RT model.

Comparison	Mean	Lower	Upper	$P(b < 0)\|\|P(b > 0)$
Intercept	0.7493	0.5948	0.9033	1.0000
TrialOrder	−0.0848	−0.1192	−0.0518	1.0000
Age	**0.3198**	**0.0989**	**0.5368**	**0.9975**
PragmaticType	**0.1002**	**−0.0393**	**0.2447**	**0.9232**
Connective	0.0616	−0.0811	0.1998	0.8090
PragmaticType.Connective	**−0.1215**	**−0.3209**	**0.0777**	**0.8810**
Age.PragmaticType	−0.0325	−0.2109	0.1393	0.6342
Age.Connective	−0.0237	−0.1957	0.1527	0.6060
Age.PragmaticType.Connective	0.0403	−0.2040	0.2945	0.6202

Bold indicates strong or weak evidence for an effect.

TABLE 6 Adults' RT model.

Comparison	Mean	Lower	Upper	$P(b < 0)\|\|P(b > 0)$
Intercept	0.3488	0.1803	0.5238	1.0000
TrialOrder	−0.1299	−0.159	−0.1017	1.0000
PragmaticType	**0.0470**	**−0.0351**	**0.1331**	**0.8758**
Connective	0.0339	−0.0488	0.1167	0.7998
PragmaticType.Connective	−0.0252	−0.1683	0.1184	0.6360

Bold indicates strong or weak evidence for an effect.

4.1 Evidence for an interaction between cognitive complexity and input

There was little evidence that cognitive complexity impacted comprehension on its own. Despite weak evidence that *if* Content sentences were easiest (for girls), this was not the case for *because*, where there were no differences in accuracy between Content and Speech-Act sentences. With RTs, there was weak evidence that children were slowest with *because* Speech-Act sentences, perhaps suggesting a role for cognitive complexity, but this was not the case for *if*. Therefore, if cognitive complexity does impact acquisition, its effects are not consistent across both connectives. However, we cannot argue that input frequency consistently predicts accuracy on these sentences, either: like the cognitive complexity prediction, the data here support the input prediction only for *if* (for girls). And for the RT data, the weak evidence that children were slowest with *because* Speech-Act sentences, suggests an unexpected and inverse relationship between RT and input frequency: while high input frequency in combination with lesser cognitive complexity results in higher accuracy (*if* Content), high input frequency in combination with higher cognitive complexity results in the slowest RTs (*because* Speech-Act). Thus, neither frequency nor cognitive complexity seems to reliably predict accuracy or RTs on their own, but children (girls, in particular) had the highest rates of accuracy on the sentence type where these cues both point in the same direction. This suggests a relationship between the two factors. That is, with *if* (unlike *because*), the cognitively simplest sentence type (Sanders, 2005; Zufferey, 2010) is also the most frequent (*if* Content) (De Ruiter et al., 2021). This interaction between input frequency and cognitive simplicity is not unlike patterns found elsewhere. For example, with regard to their finding that children performed best on *before*-sentences which appeared in a main-subordinate ordering, De Ruiter et al. (2018) suggested this might be because these sentences were not only structurally easier to process, but also had a form-meaning mapping that was more consistent in the input.

However, before we conclude that cognitive complexity plays any role in children's comprehension of connectives, we need to consider two alternative explanations that, together, point to a need for a more nuanced consideration of the role of the input. Zufferey (2010) argued that (unlike Epistemic sentences), "the enrichment required to understand the use of a connective in the content or the speech act domains is situated at the level of the content explicitly communicated in the utterance" (p. 105). In other words, children have only to pay attention to the actual content of the Speech-Act utterances to understand the link between the main and subordinate clauses. This contrasts with Epistemic sentences (e.g. You were stepping in puddles because/if your shoes are wet) where comprehension depends on understanding the meta-cognitive relation between the evidence presented and the conclusion drawn (in terms of the beliefs of the interlocutor). Because of this, Zufferey suggested there may not be a "processing cost" for Speech-Act sentences relative to Content, despite the former being more cognitively complex (in the sense of requiring an understanding of the link between the illocutionary act and its cause/conditions) than the latter. This could explain why we failed to observe a difference in accuracy for *because* Content vs. Speech Act sentences, or in RT for *if* Content vs. Speech Act sentences, but still leaves open the question of why *if* Content sentences were best understood.

In interpreting these unexpected data, we identified preliminary evidence that comprehension seems to be more strongly influenced by another factor also relevant to how children interpret *because* and *if* clauses. With RTs, in comparing the two Speech-Act sentences (and thus controlling for cognitive complexity), there was weak evidence that RTs were slower when input frequency was higher (with *because*). This leaves us with what, at first glance, seems an unlikely idea that, while input frequency plays some role in helping children understand these sentences (in combination with lower cognitive complexity), it impedes children's speed of processing of them. However, in exploring an account of how *because* and *if* Speech Act sentences may be processed, as well as considering very specific usage patterns in input, we offer an alternative explanation.

4.2 Children's interpretation of specific usage patterns in the input

Although children regularly hear *because* Speech-Act sentences, they most frequently hear them alongside illocutionary acts which encourage an immediate behavioral response: commands account for 37% of all caregiver illocutionary acts with *because* addressed to their preschool children (of 13 illocutionary acts coded, Lemen et al., 2021). As children have been shown to prioritize action responses to directives (Shatz, 1978), the tendency for *because*-clauses to co-occur with commands may impact how children learn to process these sentences. For example, if a mother says "No more chocolate, because you've already had cake today", the child may focus on the directive in the main clause, rather than the added explanation/justification for it. Indeed, Veneziano (2001) found evidence that, once children produced their own justifications to oppositional illocutionary acts, they began to ignore those produced by their mothers. Therefore, children may learn that the *because*-clause is not critical to the interpretation of the illocutionary act, itself, and is actually rather separate (i.e. what Quirk et al., 1985, p. 1070, call "disjuncts" which they argue have a more "peripheral" status).

Conversely, although *if* Speech-Act sentences also have an illocutionary act in the main clause, the performance of the illocutionary act in these sentences is considered to be contingent on the conditions in the sub-clause (e.g. Haegeman, 1984; Sweetser, 1990; Van Dijk, 1979). For example, the command in the main clause of a sentence like "No more chocolate, if you've already had cake today," should only apply if the sub-clause (you've already had cake today) is true. As such, to properly understand the illocutionary act and how it applies to them, children may learn from naturalistic speech that it is more important to interpret the main and sub-clauses together in *if* Speech-Act sentences than *because* Speech-Act sentences.

Thus, despite the overall higher input frequency of *because* Speech-Act sentences, children may be less prone to interpret the two clauses together than in *if* Speech-Act sentences. It is also possible that, rather than incrementally processing the sentence as one structure (in line with Traxler et al., 1997 account of adults' processing of complex causal sentences), children focused on the main clause of *because* Speech-Acts sentences in the present study. This may have led them to process the two clauses separately and then integrate them afterwards (more in line with Millis and Just, 1994), which could have incurred a slight processing delay relative to the other sentence types.[4] Should this be true, it would mean that processing of these sentences is, after all, impacted by input frequencies, albeit by very specific usage patterns in the input.

Although we suggested above that the higher accuracy with *if* Content was due to a convergence of cues between cognitive complexity and input frequency, it is possible that children had difficulty responding to high frequency *because* Speech-Act sentences because, despite their high frequency of occurrence, they

4 While we do not know if children do typically process complex *because*- and *if*-sentences incrementally, it seems plausible that they do, given evidence that children process simpler transitive sentences in an incremental and predictive manner (e.g. Borovsky et al., 2012).

are less used to relying on the connective to interpret a causal meaning between the clauses. Thus, these specific usage patterns could be responsible for children's difficulty with *because* Speech-Act in comparison to *if* Content, rather than the fact that the latter is less complex. Although these suggestions are based on preliminary evidence only, the results we present demonstrate the importance of fully considering the role of the language children hear when attempting to evaluate the role of cognitive complexity in language acquisition more generally. To determine the extent to which more specific usage patterns influence expectations about connective meaning and function, future studies are required to provide detailed information about how children process these sentences.

4.3 The relationship between gender, accuracy and development

The data also point to some specific gender and developmental patterns. First, while 3-year-old girls' performance was similar to that of the 5-year-olds, there was little reliable evidence that the 3-year-old boys had above chance accuracy on any sentence type.[5] Second, while there was weak evidence that children were better with *if* Content, overall, this appeared to be primarily based on the girls' data, while the boys had similar accuracy for all sentence types. In contrast to these gender differences in the accuracy data there was no evidence of a gender difference in the RT data. Thus, there seem to be differences in the order in which boys and girls acquire these sentences overall, but not how they process correct sentences. However, it is possible that the lack of gender differences in the RT data is an effect of sample size: as the 3-year-old boys had low accuracy, the RT data (which is only analyzed for correct responses) may be underpowered to pick up any gender differences, particularly if 3- and 5-year-old boys differed in their patterns.

The girls' preference for *if* Content seems to suggest that they first acquire greater competency on the sentence type which is easiest (either because it is most frequent or because it is high frequency-low complexity). The boys' equal, but slower, acquisition of all sentence types, by contrast, may mean they have a harder time establishing clear meaning for any single sentence type because of the noisiness of the form-function mapping in the input (which, Slobin, 1982 argued, can complicate acquisition). However, once they resolve this, they appear to understand all sentence types fairly equally. Thus, for girls, the pragmatic variation seems to impact acquisition of these sentences longer than boys, even though they begin to acquire them earlier.

5 While the accuracy difference between 3-year-old girls and boys could be due to differences in general language ability, we think this is not the case, as there was no consistent evidence of a relationship between gender, additional language task scores and accuracy. Furthermore, when the scores from the Digit Span and the two CELF language tasks were included in the model, the gender differences remained (see Supplementary Appendix E).

4.4 Pragmatic variation and overall acquisition of *because* and *if*

Although the data provide some evidence that comprehension is impacted by pragmatic variation, the children in this study performed well, overall. This suggests that the children (with the possible exception of 3-year-old boys) had at least a general understanding of all of the sentence types. This provides some support for Zufferey (2010) hypothesis that, although Speech-Act is more complex than Content, children have the requisite meta-communication skills for acquisition of this pragmatic type by age three.

The children's overall level of competency on this task is of note. As noted above, many studies have found that children have particular difficulty understanding *because* and *if* (e.g. De Ruiter et al., 2018; Emerson and Gekoski, 1980). However, there is a key difference between this study and many of those reporting much later acquisition of these connectives: in the present study, participants did not need to differentiate between images based on event ordering (c.f. De Ruiter et al., 2020, 2018; Emerson, 1979, 1980; Emerson and Gekoski, 1980). The present study, then, provides support for the idea that that children's comprehension of connectives at this age is still relatively fragile, restricted to certain contexts and methodologies (e.g. De Ruiter et al., 2018; Donaldson, 1986; Emerson and Gekoski, 1980; French, 1988; Peterson and McCabe, 1985). Further research could aim to disentangle the influence of the factors we have explored here in comparison to other factors, such as clause/event ordering.

5 Conclusions

This study presents evidence that both pragmatic variation and input frequency impact children's ability to interpret *because*- and *if*-sentences, although the effects change with connective and measure. Exploratory analyses provide some initial evidence that pragmatic variation may impact boys and girls differently, although further studies designed and powered to directly test the effects of gender are needed to confirm these findings. Our results suggest that these differences may be explained by children's expectations about how to interpret these connectives based on their experience with very specific patterns in naturalistic speech, raising important questions about how children process these sentences. Objective measures of complexity and form-based measures of input frequency do not consider the relevance to the child of what is being said, and how this impacts on their processing and acquisition of language. Indeed, attention to the pragmatic aspects of complex syntax is often overlooked in preference for a focus on syntactic and/or semantic factors so this study is important in highlighting the important role that pragmatics may play in acquisition.

Overall, we found little evidence in favor of cognitive complexity, alone. Rather, if cognitive complexity of the different pragmatic types does impact acquisition, it does so in combination with input. However, an alternative explanation suggests that input is actually the primary predictor for both accuracy and RT, although the input patterns that influence comprehension include both overall distributional frequency and specific usage patterns associated with different sentence types. Thus, it appears that overall distributional frequency impacts comprehension of these connectives, although more research is needed to determine whether this interacts with cognitive complexity or specific functional uses of the connectives.

In the current study, we focused on Content and Speech Act sentences with *because* and *if*, because these forms appear with sufficient frequency in the input to young children to allow us to test the effects of cognitive complexity vs. input frequency. However, the cognitive skills tested here relate only to earlier-acquired meta-communicative skills, not the more advanced meta-cognitive skills required for Epistemic relationships (Zufferey, 2010) which are beyond the scope of this study. To fully test the theory put forth from a cognitive complexity account (e.g. Sanders, 2005; Zufferey, 2010), further studies would need to consider all three pragmatic relationships and, importantly, to consider how these different pragmatic relationships are expressed in the language children hear.

Data availability statement

The datasets generated and analyzed for this study are available in the Open Science Framework repository at the following link: https://osf.io/c6g5n/.

Ethics statement

The studies involving humans were approved by University of Manchester Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

HL: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft. EL: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – review & editing. AT: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/flang.2024.1420237/full#supplementary-material

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