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The Understanding of Complex Syntax in Children From 5 to 9 Years, Using a Novel Assessment Approach – The Test of Complex Syntax- Electronic (TECS-E)

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ABSTRACT

Introduction: The present study investigated English-speaking 5–9 year olds' (n = 600, normative sample) comprehension of relative, adverbial and complement clauses using the Test of Complex Syntax-Electronic (TECS-E), an online interactive assessment. with strong test-retest reliability, concurrent validity and internal consistency.

Method: Using an opt out protocol three groups of children were recruited from schools—a sample for whom we could ascertain test-retest reliability (n = 122), a sample to explore concurrent validity, using the Test for the Reception of Grammar (TROG-2) (n = 131) and a main normative sample (n = 906). The main sample was reduced to 600, to ensure that the final sample accurately represented the population of the Republic of Ireland, with respect to sex, socio-economic status and locale. Children completed the TECS-E independently in groups within their pre/school classroom. The TROG-2 was administered individually.

Results: Scores increased with age from 5–9 years with considerable growth in development between 5;06 and 7 years, suggesting that 7 years is an important milestone in children's understanding of complex syntax. Girls performed significantly better than boys, particularly between 6 and 7 years. Those from disadvantaged backgrounds scored significantly lower than those who were more affluent, until 7 years, and this was more marked in boys than in girls. Children performed highest on relative clauses, followed by complement clauses, and last on adverbial clauses.

Conclusion: This study provides a developmental hierarchy as well as important information regarding growth in English-speaking children's understanding of complex syntactic structures in the early school years and how this interacts with sex as well as social disadvantage.

WHAT THIS PAPER ADDS

What is already known on the subject

- Complex sentences play a crucial role in children's language and literacy development. They become increasingly relevant as children progress through school, from both an academic and social perspective. Despite this, we lack a comprehensive picture of children's understanding of these types of sentences.

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What this paper adds to the existing knowledge

- This is the first study to report on a large sample of English-speaking children's understanding of complex syntactic structures between 5 and 9 years. In addition, the assessment tool used (the TECS-E) has been designed to reflect how children process language in everyday interactions, and to include constructions that follow the linguistic patterns of those that children say and hear in natural discourse.

What are the potential or actual clinical implications of this work?

- This study furnishes a reference dataset of the growth in typically developing children's understanding of complex sentences. This information can be used by clinicians to identify gaps in understanding and to guide the design and delivery of syntactic interventions.

1 | Introduction

Mastery of complex sentences is central to children's academic success in school and is required to understand and engage in successful conversations in everyday interactions (Balthazar and Scott 2024). They are required to convey information, to understand questions requiring evaluation or analysis, to explain complicated material, and to develop social relationships. Despite this, we lack a comprehensive picture of children's understanding of these types of sentences. The majority of relevant studies have relatively small sample sizes and have focused on children's production of complex sentences rather than their understanding of them (e.g., Berman and Nir-Sagiv 2009; Diessel 2004; Westerveld and Vidler 2016). Furthermore, commonly used comprehension testing methodologies (such as multiple-choice sentence picture matching tasks) invoke additional processing skills and load in addition to those of linguistic competence (Frizelle et al. 2017). In addition, many commercially available tests have been deemed problematic, in that the constructions tested are very different from those that young children say and hear in natural discourse (Diessel and Tomasello 2005). This study seeks to address these gaps in knowledge and methodological issues through the collection of a large dataset characterising typically developing children's understanding of complex sentences, using a novel assessment tool designed to minimise the processing load for children and in which the constructions are similar to those young children say and hear in everyday discourse.

1.1 | Syntactic Constructions

In broad terms, syntactic constructions can be defined as either simple, compound or complex. A simple sentence consists of a single independent clause, involving ordered elements functioning as the subject (S), verb (V), object (O) or complement (C) and adverbial (A) of that clause (Quirk et al. 1985). The set of elements can be exemplified in the sentence, The man (S) will buy (V) the car (O) tomorrow (A). Minimally, clauses require a verb or verb phrase. Compound sentences are independent clauses linked by conjunctions such as *and*, *but*, *or*, and we do not deal with them further here. Complex sentences contain two or more clauses linked through a process of subordination. One clause serves as the main clause, and the other is deemed the subordinate clause, as it is subordinate to or embedded within the main clause and cannot stand alone. Here we investigate three discrete families of complex constructions: adverbial clauses, complement clauses and relative clauses. Examples of the constructions discussed here are included in Table S1.

Adverbial clauses modify all of the main clause and are linked semantically, most commonly using temporal (e.g., after) or causal (e.g., because) connectives. Adverbials can be iconic (where the order of mention follows the order of events), as in the sentence *The boy played football before he watched TV*, or non-iconic (where the order of mention is in contrast to the order of events), as in the sentence *The girl opened the box after she put on her slippers*. Adverbial clause constructions can also be used in two clause orders—subordinate-main (as in the sentence *If the man moved his legs, the woman could sit down*), or main-subordinate (shown in the sentence *The woman could sit down if the man moved his legs*).

In the second family of constructions, complement clauses, the embedded sentence functions as one of the arguments of the verb in the main clause, such that the complement can be the subject, direct object, or indirect object of the main verb (Quirk et al. 1985). For example, in the sentence *She knew the boy was hungry*, *the boy was hungry* is an object complement of the main clause. The main verbs are usually categorised as those of desire or perception as well as mental state, manipulation, or communication verbs (Diessel 2004; Owen Van Horne and Lin 2011). Embedded clauses can also be finite (where the verb is marked for tense) or non-finite (where the verb is not marked). With respect to complement clauses, this distinction is shown in the following two sentences *She realises that her jacket is not there anymore* (finite), in contrast to *She can't see the man take her jacket*, where tense is unmarked (non-finite).

In contrast, relative clauses function to postmodify a noun or noun phrase. Relative clauses are usually defined by two key aspects: (1) the sentential position of the noun phrase which includes the relative clause and (2) the role played by the relativised noun in the embedded clause. In *He found the girl that was hiding*, the noun phrase (underlined) containing the relative clause is in Object position in the sentence overall. In terms of the role of the relativised noun, *the girl* operates as, at once, the object of the verb *found*, and the subject of the verb phrase *was hiding*. Compare another sentence in which the same NP is in Subject position in a sentence: *The girl that was hiding fell asleep*. In another sentence, *The boy picked up the cup that she broke*, the

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NP containing the relative clause is again in Object position in the sentence. And the NP *the cup* is again the object of the verb in the main clause. But its role in the relative clause is different. Even though it is not expressed in the usual postverbal position, we understand it to be the object of the relative clause verb *broke*. There are further possible roles that the relativised noun can play, for example, subject, oblique and indirect object, that we will return to. Complex sentences in English are described in more detail in Diessel (2004), Huddleston et al. (2002) and Quirk et al. (1985).

1.2 | Adverbial Clauses in Typically Developing Children

Studies have yielded conflicting results both with respect to children's ability to understand sentences with adverbial clauses, as well as the factors proposed to influence their comprehension of these constructions. Children start to use adverbial clauses around the age of 3 years (Diessel 2004). However, they appear to have difficulties understanding these sentences well into their primary school years and beyond (Cain et al. 2005; Emerson and Gekoski 1980; Pyykkonen and Jarvikivi 2012). Reasons for this discrepancy have been attributed to the specific nature of the experimental test sentences used (e.g., not mirroring those used in spontaneous speech) (De Ruiter et al. 2021; Diessel 2004), as well as assessment methodologies with too high a cognitive load (French and Nelson 1985).

In addition, there are a number of semantic, syntactic and pragmatic factors thought to influence children's understanding of these constructions. The specific adverbial connective is one factor which we expect to influence children's understanding. It has been suggested that some adverbials are semantically simpler than others, such as *before* versus *after* (Clark 1971) (in that *before* typically refers to an event earlier than another event in a linear fashion, whereas *after* can refer to not just a moment in time but a range of time). However, while findings from several studies support this theory (e.g. Blything et al. 2015; Blything and Cain 2016; De Ruiter et al. 2018), others present contradictory findings (e.g., French and Brown 1977; Gorrell et al. 1989). Furthermore, some adverbials express one relationship, such as temporality (*before* and *after*), whereas others require an interpretation of both time and causality (*because*) or conditionality (*If*), in order to process them accurately (Emerson and Gekoski 1980) and are therefore deemed more complex.

In line with a usage-based approach, we would also expect the frequency with which a connective is used in children's linguistic environment to impact their comprehension. Corpus data from American English-speaking children 1;08 to 5;01 years, analysed by Diessel (2004), supports this relationship for some adverbial connectives. For example, *because, when* and *If* are among those produced earliest by children (2;05, 2;10 and 3;0 years respectively) and used most frequently in parental input. In contrast *before* and *after* do not appear until later (3;02 and 3;04 years) and are rarely heard in the parental input. However, the role of frequency does not account for other patterns of connective use, in that *so* and *but* are produced much earlier than *when* and *if*, even though the latter connectives are produced with greater parental frequency.

An additional aspect of variability relates to iconicity, such that several studies have shown that children find it easier to understand sentences with temporal connectives that are iconic (where the order of mention is in keeping with the order in which the events happened—for example, *She drank the milk before she ate the biscuit* versus *Before she ate the biscuit she drank the milk*) (Blything et al. 2015; Clark 1971; De Ruiter et al. 2018) while other studies found no such advantage (Gorrell et al. 1989). Inconsistent findings are also reported for causal and conditional sentences, with some studies supporting an iconic advantage and others not (e.g., Kuhn and Phelps 1976). From a syntactic perspective, it is suggested that adverbials that follow a main-subordinate clause order are less taxing on working memory and should therefore be easier to process (Diessel, 2005). Again, results are conflicting with some studies corroborating this theory (Amidon and Carey 1972; Johnson 1975) and others not (Amidon 1976; De Ruiter et al. 2018). An interaction between frequency and clause order has also been reported, which may mitigate any suggested working memory load. For example, *if*-sentences occur primarily in subordinate-main order, whereas *before*- and *because*-sentences occur primarily in main-subordinate order (De Ruiter et al. 2017). In summary, for reasons already stated, for example, methodologies used, types of test items, many experimental findings are contradictory with respect to children's understanding and use of adverbial clauses, and there is no comprehensive picture of the order in which young children understand adverbial clauses with a range of functions. Consequently, there is no normative dataset against which young English-speaking children's understanding of these constructions can be compared.

1.3 | Complement Clauses in Typically Developing Children

Complement clauses are reported to be the earliest family of complex sentences used by children, emerging between 2;0 and 3;0 years (Bloom et al., 1989; Diessel 2004; Diessel and Tomasello, 2001). With respect to order of acquisition, simple infinitives (e.g., I need to go toilet) are produced first (Bloom et al. 1984), followed by sentential complements (e.g., I pretended that Dolly had a bath) and wh-complements (e.g., I know where Teddy is; Diessel 2004), while non-finite clauses containing a subject before the infinitive construction (e.g., The girl wanted Mum to play house) emerge later (Paul, 1981). With respect to specific complement taking verbs, children's development of mental verbs is later (with a longer trajectory) than those that are more concrete (Berman 2009).

Children's understanding of sentential complements has been much less thoroughly investigated. Developmentally, complement-clause constructions with desire verbs (such as *want*) are reported to be understood before those with mental or communication verbs (such as *say*) (Perner et al. 2003), however, much of the comprehension work has focussed on the relationship between complement clause constructions and

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children's understanding of false belief tasks. Historically, it was suggested that an understanding of complement-clause constructions was necessary to represent and develop an understanding of false belief. However, crosslinguistic work has challenged this premise and indicated that it is only those with mental state (e.g., *think, know*) and communication verbs (e.g., *say, tell*) that are associated with false belief understanding and not verbs of desire (e.g., *want, wish*) (see de Villiers and Pyers 2002 [English]; Perner et al. 2003 [German]; Cheung et al. 2009 [Chinese]). Further nuances indicate that 4-year-old children's understanding of their own false beliefs has been associated with their understanding of 3rd rather than 1st person complement constructions (*He thinks…* vs. *I think*) (Brandt et al. 2016).

In keeping with a usage-based approach, the frequency with which a verb normally appears in a syntactic construction also appears to impact children's performance on sentences containing complement-taking verbs. Kidd et al. (2006) reported that children 2;10 to 5;08 years could more accurately repeat and correct sentences that contained high frequency complement taking verbs relative to those of lower frequency.

As is the case with adverbial clauses, there is no comprehensive picture of the order or degree to which children between 5 and 9 years understand sentential complements with a range of functions. And consequently, no normative dataset against which young English-speaking children's understanding of these constructions can be compared.

1.4 | Relative Clauses in Typically Developing Children

Historically, relative clause research indicated that while children were able to produce relatives before the age of 3 years, they continued to have difficulty comprehending them at age 5 (e.g., de Villiers et al. 1979; Sheldon 1974; Tavakolian, 1981). This is in contrast to what is generally reported with respect to child language development, in that children usually understand in advance of their ability to produce. In keeping with the adverbial clause literature, this discrepancy has been attributed to the types of constructions tested in comprehension tasks as well as the testing methodologies used (Frizelle et al. 2019a). Frizelle et al. (2019a) reported two different hierarchies of performance in 3½ to 4½ year old English-speaking children: on a sentence-verification task, the pattern was two tiered that is, intransitive subject > transitive subject = object = oblique relatives = indirect object (where > refers to 'significantly greater than' and = refers to 'no significant differences') whereas on a multiple-choice task the pattern was three-tiered that is, intransitive subject = transitive subject > oblique = object > indirect object relatives. Using sentence repetition, Diessel and Tomasello (2005) presented a similar hierarchy of performance in typically developing 4-year-old English-speaking children. Across each of these studies an advantage is shown for at least one form of subject (transitive or intransitive) versus object relative. This subject relative advantage has also been reported in other languages, including, for example, Dutch (Frazier 1987) and German (Schriefers et al. 1995). However, a subject relative advantage is not universal, with an object relative advantage reported in Japanese (Suzuki 2011) and Mandarin Chinese (He et al. 2017). In English, the suggestion is that because subject relatives maintain the canonical word order (SVO) of the constituents (*He found the girl that was hiding*), they are easier for young children to process. In contrast, in object relatives the word order is non-canonical (OSV) (*This is the boy that the girl teased at school*) and therefore, to parse the sentence correctly, children are required to understand that to find the object of teased (the boy), they have to refer back to the relative pronoun. However, work by Kidd et al. (2007) suggests that this processing cost can be mitigated by specific realisations of the object relative construction (namely, those with an inanimate head noun and a pronominal subject in the relative clause position—for example *There is the book that you read last night*). Kidd and colleagues found that when children were tested on these types of relatives (i.e., those that they are more likely to say and hear), they no longer showed an advantage for subject relatives. This lack of asymmetry between subject and this subtype of object relative was also borne out in findings by Frizelle and Fletcher (2014) and Frizelle et al. (2019a).

1.5 | Complex Syntax With Respect to Age, Sex and Social Disadvantage

Growth in the use of complex syntax with age has been well documented in the empirical literature. For example, Morton and Schuele (2021) reported a developmental progression in preschool children's ability to imitate sentential complement sentences. Using narrative tasks, Guo et al. (2021) reported higher clausal density for 7–9-year-old children relative to 4-, 5- and 6-year-olds, while Frizelle et al. (2018) found that the number of clauses per utterance increased steadily from 4 years into adulthood. In addition, using conversational language samples, Owens et al. (2024) reported an increase in the production of co-ordinate and subordinate clauses between 5 and 10 years. Growth in children's understanding of complex syntax has been much less examined. In the United States, Jiang et al. (2018) carried out a 5-year longitudinal study of grammar with children from preschool to 3rd grade (8–9 years), using multivariate growth curve modelling. Grammar was measured using standardised tools, including the Test for the Reception of Grammar (TROG) and the Clinical Evaluation of Language Fundamentals (CELF) Sentence recall subtest, in which some complex syntactic structures are embedded. Jiang and colleagues found that children's grammar continued to improve incrementally, with a metric of 3.08 SD units (Cohen's d) over the 5-year period. To the best of our knowledge, no study has focused specifically on children's understanding of a range of complex structures in English from 5–9 years.

With respect to sex differences, it has long been reported that boys and girls differ in their rate of overall language development; however, these differences are often not significant and tend to interact with other factors such as age and task (Etchell et al. 2018). Boys represent more than 70% of late talkers (Kovačević et al. 2007); are more likely to be identified as at risk for language disorder at screening (Norbury et al. 2016); have been shown to produce word combinations on average 3 months later than girls (Ozçalişkan and Goldin-Meadow 2010) and are slower in lexical (Carpenter et al. 1998) as well as grammatical development (Kovačević et al. 2007). Interestingly, when examined over a 5 year period, sex was found to predict baseline scores but not the developmental trajectory of grammar (Jiang et al. 2018). In general, sex

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differences decrease with age (Lange et al. 2016) and, as noted by Adani and Cepanec (2019, 143), 'the greatest differences between sexes are noticed at the points of development when children master new communication and language skills'. To the best of our knowledge, no study has examined sex differences focusing specifically on children's comprehension of complex syntactic structures in English.

The association between children's socioeconomic environment and their language outcomes has long been established, such that those living in poorer circumstances have poorer outcomes across a number of language domains (Dollaghan et al. 1999; Hoff 2006; McDowell et al. 2007; Pan et al. 2005). Focusing specifically on complex syntax, Huttenlocher et al. (2002) examined English-speaking 4–5-year-old children's understanding of sentences, including adverbial and relative clauses, and reported a significantly lower performance in children from disadvantaged backgrounds, relative to their more affluent peers. Similarly, Levine et al. (2020) reported a significant effect of socio-economic status (SES) in 3–5-year-old children's understanding of syntax, using the Quick Interactive Language Screener, which incorporates both simple and complex syntax. This SES gap is also evident expressively. Vasilyeva et al. (2008) examined English-speaking children's sentence production longitudinally (aged 26–42 months), again from diverse socio-economic backgrounds. While they reported no group differences in children's production of simple sentences, a significant gap was evident in children's production of complex sentences. This gap was evident from 26 months and reflected both the frequency with which children produced complex sentences and the number of types of complex sentences produced across the age range. Moreover, the growth curves indicated a further widening of the gap between 30 and 42 months, a finding reinforced by Huttenlocher et al. (2010) with respect to diversity of syntactic clauses produced at this age. Research on children's understanding of complex syntax in the preschool years (43–50 months) suggests that this gap stabilises and that growth in children's syntactic comprehension is explained by teachers' use of complex sentences rather than their socio-economic background (Huttenlocher et al. 2002). This stabilisation is in keeping with Jiang et al. (2018) who found that when examining children's grammar trajectories (up to between 8 and 9 years), including both simple and complex sentences, maternal education predicted children's performance at baseline, but not their developmental trajectory. Overall, the literature converges on the view that young children from disadvantaged backgrounds have reduced knowledge of complex syntax compared to their more affluent peers, but language exposure in school may serve to mitigate these effects.

1.6 | The Current Study

The current study addressed the aforementioned knowledge gaps in the literature through a comprehensive examination of children's understanding of relative, adverbial and complement clauses in children from 5–9 years. This was essentially a descriptive rather than a theoretical study. Our aim was to examine how children's understanding of different clause types changed with age and to examine developmental patterns between 5 and 9 years. Through the use of the TECS-E, a novel assessment tool designed to minimise the cognitive processing load for children and in which the constructions tested are reflective of those used in natural discourse, we could obtain a more ecologically valid profile of children's understanding of complex sentences within this age range.

Through the collection of a large dataset (reflective of the Irish population), we could also examine the effects of sex and social disadvantage on children's comprehension of these complex syntactic structures. Based on previous literature, we predicted that boys would perform lower than girls in the younger age groups but that this gap would no longer be evident as children's language matured. In addition, we predicted that those living in more socially disadvantaged areas would have greater difficulty understanding complex sentences than their more affluent peers. However, given the influence of teachers' language input in school we predicted that this difference would no longer be evident among the older children in the sample.

The specific research questions addressed by this study were as follows:

- How well can English-speaking children between 5 and 9 years understand complex sentences (specifically relative clauses, adverbial clauses and complement clauses) when assessed in a manner that is more closely related to processing language in natural discourse (using TECS-E)?
- How does the type of construction, age, sex and SES impact children's performance?
- Within each family of constructions, what is the order of difficulty in the types of sentences understood?

Although the TECS-E has been reported on in previous studies (Frizelle et al. 2024; and an earlier version in Frizelle et al. 2019a, 2019b), prior to examining our research questions about typical development, we wanted to establish the reliability and validity of the tool. We did this through test-retest and an investigation of whether there was an association between children's performance on the TECS-E and their performance on another test of children's understanding of grammar (The Test for the Reception of Grammar-2nd edition (TROG-2). While we anticipated some degree of association between the two measures, given that the TROG-2 focuses more on simple syntax (with few complex structures), we did not predict a strong as sociation.

2 | Method

2.1 | Participants

Three groups of participants were recruited—a main normative sample, a smaller sample for whom we could ascertain test-retest reliability, and a further sample to explore the relationship between children's performance on the TECS-E relative to the TROG-2 (Bishop 2003). For the main sample, 50 primary schools and 9 preschools were invited to take part in the study between January and November 2022. Seventeen schools and four preschools agreed to participate, and all were included in the

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data collection process. The schools and preschools represented the four provinces of Ireland and were sufficiently diverse to ensure an accurate representation of SES, geographic location (i.e., rural or urban), and sex, in keeping with the most recent 2016 Irish population Census report (Central Statistics Office, n.d.). The participants' socio-economic background was determined at the school level using the POBAL[1] (Pobal 2016) map to identify schools in disadvantaged areas.

Preschools and schools were initially contacted by email and subsequent phone calls. To ensure a less biased sample, we adopted an opt-out approach, in which every student in the school who met the criteria for the study was included in the project unless their parent(s) or caregiver(s) chose to opt out. In keeping with ethical approval, preschool managers and school principals who agreed to participate could choose to inform parents about the project electronically, and/or by distributing information letters in hard copy. All preschools and schools opted for electronic communication (by email or a dedicated school app) to align with their established communication practices. Parents received the project information and an opt-out form a minimum of 2 weeks before the testing took place in the school. Parents could opt out by signing and returning the opt-out form or by simply informing their child's teacher verbally or via email. Only one parent chose to opt out.

Children were included on the basis that they (i) were between 5;0 and 8;11 years, (ii) had no diagnosed hearing or learning difficulties, and (iii) spoke English as their primary language at home. For the main sample, a total of 906 children who met the inclusion criteria were initially tested. This sample was subsequently reduced to 600 (i.e., 100 children per age bin), using random stratified exclusion, to accurately reflect the Irish population in terms of SES, sex and geographic location, based on the most recent figures available from the Central Statistics Office 2016 census (i.e., 49.66% male, 50.34% female, 31.4% rural, 11.6% low SES). Rurality is defined by the population size and density (areas with <1500 people), while SES is indexed by the 2016 Pobal (HP) Deprivation Index.

In relation to the test-retest participants, we aimed to recruit a minimum of 100 children with a reasonably even spread across the age bins. Fifteen primary schools were invited to take part between September 2022 and September 2023. Eight schools did not reply to the initial recruitment email. The seven that did receive a follow-up phone call discussing the study in detail and logistical requirements. All seven schools were satisfied with the testing procedure and consented to participate. Finally, for the sample who completed both the TECS-E and the TROG-2, we aimed to recruit a minimum of 100 children. Ten primary schools were invited to take part between September 2022 and September 2023, via email. Six schools replied to the initial recruitment email and received a follow-up phone call. All six agreed to participate and were included in the data collection process. Half of the schools invited Junior and Senior infant pupils to participate (the first and second year of primary school), while the remaining half invited their First- and Second-class students (the third and fourth year of primary school). Only pupils that met the inclusion criteria completed the TROG-2, individually, with a research assistant. The recruitment process was similar for all three population samples and children from all 6 age bins were represented in each sample. Demographics for each sample are shown in Table 1.

3 | Measures

3.1 | The TECS-E Complex Syntax Comprehension Task

The Test of Complex Syntax-Electronic (TECS-E) was the assessment was used to test children's understanding. The test has been developed to test children's understanding and to be used as a self-directed assessment on a tablet or computer device. Reliability for children to use it independently from 5 years has previously been established (see Frizelle et al. 2024). The assessment is an animated sentence comprehension task that uses a truth value judgement paradigm. Children are shown test animations (approximately 6 s in length), each with an accompanying auditory test sentence. All test sentences are pre-recorded by a native female English speaker, delivered by *Bella* the animated Bunny, within the app. Test sentences accurately describe the animation for half of the items, and for the remaining items test sentences and animations are incompatible. At the bottom left and right corners of the screen, there is a ✓ and an X. Children are asked if what is shown in the animation matches the sentence they hear and to respond accordingly by touching either the ✓ or the X on the screen.

The test animations represent 4 types of adverbial clause (before, after, because and if), 4 types of sentential complements (think, know, pretend and wish) and 3 types of relative clause (intransitive subject, transitive subject and object). There are an additional 10 simple *'catch item'* sentences, designed to identify children showing a yes bias. Ten motivational star animations are also integrated into the test.

The types of test sentences used within each family of constructions were chosen with reference to usage-based linguistic theory and research. Four types of adverbial clauses were included, to encompass those used in child language with a range of frequency (see Diessel 2004) and a range of functions (two temporal (before, after), one causal (because) and one conditional (if). Item demands are somewhat dependent on the family and subtype of complex sentence. With reference to our examples in Table 2, in the case of *If* adverbials a level of complex reasoning is required to understand that *If the gate was open, the horse could* ***not*** *walk away*, as it is tied to a pole. *Because* adverbials require an understanding of causality (which often includes temporal information) and therefore children are required to determine if the boys' laughing was caused or in some way related to the clown falling over. Lastly, temporal adverbials such as before and after require children to process which action happened first that is, whether *the boy* ***did*** *play football before he watched TV*. Temporal adverbials were those in which the events did not typically occur in a set order (such as she put on her socks before she put on her shoes), and therefore, children's interpretation could not rely solely on world knowledge. Iconicity was also controlled for across each adverbial type, such that in half the adverbial constructions the clause order reflected the order of events in the real world, while in the remainder of items the order was reversed. Within *before* and *after* adverbial sentences, there were

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TABLE 1 | Standardisation, test-retest and TECS-E/TROG-2 samples based on sex, geographical location and socio-economic status.

			Sex				Geographic location						SES					
			Female		Male		Urban		Rural		Affluent		Marginally above average		Marginally below average		Dis-advantaged	
			N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Standar-disation	Age group	5;0–5;5	52		48		73		27		5		54		22		19	
		5;6–5;11	52		48		70		30		8		39		34		19	
		6;0–6;5	46		54		66		34		8		31		43		18	
		6:6–6;11	56		44		55		45		12		25		56		7	
		7;0–7;11	42		58		68		32		12		36		42		10	
		8;0–8;11	55		45		81		19		17		46		29		8	
	Total ($n = 600$)		303	50.50	297	49.50	413	68.83	187	31.17	62	10.33	231	38.50	226	37.67	81	13.50
Test retest	Total ($n = 122$) 5;01–8;11		61	50.00	61	50.00	114	93.44	8	6.56	65	53.28	37	30.33	20	16.39	0	0.00
TECS-E/TROG 2	Total ($n = 131$) 5;01–8;08		70	53.44	61	46.56	113	86.26	18	13.74	16	12.21	73	55.73	15	11.45	27	20.61

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TABLE 2 | Example of test sentences for each structure.

Sentence type		Example sentence	YouTube video link
Relative clause			
	Subject intransitive	He found the girl that was hiding	https://youtube.com/watch?v = bA6QCvVs4j4
	Subject transitive	He sat on the girl that was drinking the juice	https://youtu.be/mZJLIH6fzVk
	Object	The boy picked up the cup that she broke	https://youtu.be/5SevvmcFb9Q
Complement clause			
	Think	She thinks the boy's hair is dry	https://youtu.be/No8Cg4hPECE
	Wish	The girl wishes she won the race	https://youtu.be/huGslg0_zSw
	Know	She knows the man took her dog	https://youtu.be/uyGXNqooyKs
	Pretend	The man is pretending he fell in the hole.	https://youtu.be/C42lo63Uu48
Adverbial clause			
	Before	The boy played football before he watched TV	https://youtu.be/A58z4WxB1PQ
	After	The girl opened the box after she put on her slippers	https://youtu.be/uUxdd_BL5wY
	Because	The boy laughed because the clown fell over	https://youtu.be/RFybPX_lSFc
	If	If the gate was open, the horse could walk away	https://youtu.be/yd4iw http://5beHCc

an even number of main-subordinate versus subordinate-main constructions. For *If* constructions, 6 of the 8 test items were subordinate-main (3 congruent and 3 incongruent) and 2 main-subordinate (1 congruent and 1 incongruent), and for *Because* constructions the reverse was the case (6 of the 8 test items were main-subordinate and 2 subordinate-main). This allowed us to control for i) children using a strategy based on iconicity and ii) clause order preferences in relation to frequency data (i.e. *if* sentences occurring more frequently in subordinate-main order, whereas *because* occurs primarily in main-subordinate order.

Sentential complements were those that contained a finite verb in the complement clause and included those in which both the complement and matrix clause had subjects, and a third-person pronominal subject in either the complement or the main clause, for example, He knows the girl broke the chair. They were chosen so that three of the complement-taking verbs were mental state verbs (think, know, pretend) and one represented desire (wish). These were informed by acquisition data reported by Diessel (2004), again representing a range with respect to how frequently they are used by young children as well as those that could be adequately represented through animation. To assess *think* and *know* items we use a false belief task, an understanding of which children would typically have by the age of 5 years. Our assessment of wish complements is based on the premise that you do not typically wish for something that you already have/did, for example, the girl does not wish that she won the race if she already did. *Pretend* constructions require children to determine whether something really is the case (e.g. the man is not pretending he fell in the hole if he really did fall in the hole) or to have some understanding of symbolic play (e.g. the use of a banana as a phone).We expect this type of play to be well developed by 5 years (Piaget 1951).

Finally, three types of relative clause constructions were included based on previous work by Diessel and Tomasello (2000, 2005), Frizelle and Fletcher (2014) and Frizelle et al. (2019), indicating a performance hierarchy in children's knowledge of these constructions. All were fully bi-clausal and designed to reflect structures that are used in natural discourse, that is, they were attached to the direct object of a transitive clause and object relatives had an inanimate head noun and a pronominal subject (see Kidd et al. 2007). All constructions included high-frequency nouns and verbs based on the British National Corpus. Task demands within our assessment of relative clauses required children to distinguish two referents (i.e., the head noun from the noun to which the relative clause refers) and to map the thematic roles to the appropriate verb argument structure. In the Table 2 animation, we can see that *he sat on the girl* but not the one *that was drinking the juice*. To understand this construction, the child needs to distinguish between both referents

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and to complete the appropriate thematic role to verb argument mapping.

The TECS-E assessment has been designed to closely mirror language processing in natural usage. The advantage of using individual animations with a truth value judgement paradigm is that children can simultaneously evaluate the truth of each construction directly against the animated scenario, as it is occurring, and consequently, they do not have to store the arguments associated with each verb in memory. In this regard, the memory load is similar to that required when processing language in everyday discourse. This contrasts with the more usual multiple choice sentence picture matching task in which the correct representation and three foils or competitors would be typically presented. The child is therefore required to actively rule out three competitors, which significantly increases the cognitive load of the task (see Frizelle et al. 2017).

In TECS-E the foils are built into each individual animation. For example, recall that in the case of relative clauses, there is always an alternative to the head noun to which the relative clause refers, that is, a referent from which another can be distinguished. As an example, the intransitive subject relative *He found the girl that was hiding* implies that there is another girl who is not hiding, and this is represented within the animation. Using this method, children are required to make a semantic evaluation of a given sentence and to map the thematic roles to the appropriate verb argument structures, as they would in a natural context. They do not have to actively rule out three competing alternative mappings (i.e., *She found the boy that was hiding; The boy that was hiding, found the girl; The girl that was hiding, found the boy*). However, because children have a 50% chance of getting the item correct, each construction needs to be represented multiple times, and it is only in the analysis of both the compatible and incompatible items together, that we can get an accurate picture of what children understand (see Frizelle et al. 2019). This is clear in the case of the compatible *know* constructions, where one could argue that a child could achieve the correct response by understanding the simple sentence that follows the *know* verb. For example, *she knows the boy ate the sweets* is depicted with a girl looking directly at the boy eating sweets, and if the child processes the sentence as *the boy ate the sweets*, then he or she will get it right. It is only when we combine these responses with the false items that we have the complete representation of the child's understanding. In contrast, the reverse is the case for the *think* items, where the compatible items reveal more about the child's understanding. As an example, the true item, *She thinks the cat is in the basket*, involves a scenario where the cat was in a partially covered basket, the lady turns away and leaves the room, the cat jumps out of the basket and runs away, the lady comes back and therefore she does indeed think the cat is in the basket. If the child processes this as a simple sentence, *the cat is in the basket*, they will get the item wrong.

Therefore, it is the pattern of results that the child shows across all items that allows us to profile their understanding, that is, they need to get both true and false items correct to show complete understanding. Example test sentences for each structure (including true and false items) along with their respective YouTube links are provided in Table 2.

3.2 | TROG-2

The TROG-2 (Bishop 2003) is a multiple-choice sentence picture-matching task, developed to assess understanding of 20 constructs. It is designed for use with children from 4 years into adulthood and is considered a valid and reliable measure (test retest reliability and internal consistency = 0.88, content validity = 0.79). The TROG-2 was administered using the standard procedure. For each item, children were presented with a choice of four pictures. They listened to a target word or sentence and were asked to identify the corresponding picture. Items were presented in order of difficulty, beginning with single words, followed by syntactically simple sentences and progressing to those that were more complex. Items were presented in blocks of 4 with each block focusing on a particular structure. In order to pass a block, children were required to pass all four items. As outlined in the manual, testing was discontinued when five consecutive blocks failed.

3.3 | Procedure

In primary schools, we took an inclusive approach such that all children who wanted to take part (and whose parents had not opted out) were included in the activity. Those who did not meet our inclusion criteria were allocated an XX code, so that their data could be easily excluded from the analysis. Children who opted out of the study were taken to a different room to complete a separate school task. In contrast, in preschool, only children who met the minimum age criteria participated, as very young children would not have been able to complete the assessment independently. Preschool children who did not meet our remaining inclusion criteria were managed similarly to the school-aged children.

All participants completed the assessment individually but in a group context. Due to the small number of 5-year-olds in the preschools, they were brought into a different room to complete the app at the same time, in the presence of two RAs and a preschool staff member. For those in their first year of primary school (i.e., children aged 5 to 6 years of age), classes were divided into two groups of up to 15 children to minimise the effects of reduced attention and listening skills. Every child received their own tablet and set of headphones, which were sanitised after every use. Tablets and apps were configured prior to meeting with the participants. The researchers were given a class list with children's names, date of birth and gender. An anonymous alphanumeric code was allocated to each child and entered into the app, along with their sex and date of birth. The latter was immediately converted to age in days so that no identifying information was stored. A Post-it was used to label each tablet with the child's name. The class lists and Post-it labels were given to the preschool or school for shredding at the end of each testing session. Researchers maintained a database in Excel with the children's anonymous codes, age and sex, to monitor and track participants.

Two researchers managed the testing procedure, one introduced the team and the activity to the class, while the other distributed the tablets and headphones. Children were told that they would play a game on a tablet with a bunny called Bella, who loved

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talking. They were instructed to listen to Bella, decide when she was 'right' or 'made a mistake', and navigate through four levels of the game. The researchers explained that the initial three levels served as practice rounds and reassured children not to worry if they encountered difficulties in these levels, as Bella would help them. Children were made aware that level 4 was the 'real game', and that Bella would give them 10 stars as they played the game. A crucial rule (i.e., 'no talking' during the game) was established with every class. The researchers discussed the potential excitement of earning stars and the desire to share this achievement with others, and how this might negatively impact other children's ability to attend and listen. Each class collectively brainstormed silent celebration methods, resulting in some creative ideas like 'wiggling in their chair'. In addition, the two researchers circulated the classroom during the activity, strategically standing or sitting next to children displaying diminished attention and listening. Upon finishing the app, children received a sticker and an activity to complete (typically a book or a colouring page) while waiting for their peers to finish. Data from the TECS-E app was automatically collected and stored electronically on the Firebase servers, where the animation task is hosted.

Children who completed the TECS-E twice (test re-test) did so no more than 1 week apart. The TROG-2 was completed on the same day as the TECS-E.

3.4 | Data Analysis

All statistical analyses were performed using Statistica 7.1 (StatSoft, Inc., 2005). Internal consistency of TECS-E was calculated using McDonalds Omega, which is used for composite standard scores (to ensure equal weighting) and Cronbach's alpha was calculated to give an index of reliability for total mean raw scores, within each family of constructions. Test—retest reliability was examined using a Pearson's product-moment correlation coefficient for paired samples (where the independent variable was time and the measured variable was the percentage of items correct). However, because the correlation measures only the strength of the relationship between the two variables, but not the agreement, a Bland–Altman analysis was also completed (Bland and Altman, 1995). In a Bland–Altman the difference between the scores at two time points is plotted against the mean of the two time points. This method allows the mean difference between the two time points of assessment (the 'bias') to be calculated as well as the 95% limits of agreement of the mean difference. Pearson's product-moment correlation coefficient for paired samples was also used to explore any potential relationship between the TECS-E and TROG-2.

Children's overall understanding of complex sentences (adverbial clauses, complement clauses and relative clauses) was determined by calculating the total average score (measured as percentage of correct answers) that children achieved on TECS-E per age bin. A similar metric was used within each family of constructions. A full factorial ANOVA was conducted to examine the effect of type of construction, age, sex and socioeconomic status on children's understanding of complex sentences as well as any potential interaction between these variables. An ANOVA tests the null hypothesis, that is, it provides the probability that each of the effects considered is negligible. A 95% confidence level was chosen. The full factorial ANOVA creates a linear model that includes main effects and interaction effects. As *type of construction* is composed of three different group means (i.e. relative clauses, complement clauses and adverbial clauses), a post-hoc analysis with Fisher Least Significant Difference (LSD) was also used to identify significant differences between scores on each type of construction. The Fisher LSD method calculates the least significant difference between the means of all possible pairs of groups, while taking into account the variability within the groups and the overall error rate. Fisher LSD was chosen because (i) it is commonly used in analysis of data characterised by substantial variability, and (ii) the significant difference values derived from Fisher LSD are notably smaller number than those provided by the other two commonly used post-hoc tests (i.e., TUKEY Honest Significant Difference and the Bonferroni Correction).

To investigate the order of difficulty in the types of sentences understood by children within each family of constructions, the full factorial ANOVA was repeated, replacing the families of constructions with the 11 types of sentences within them. The FISHER LSD post-hoc analysis (at 95% confidence level) was again used to identify the value for the significant difference between means. This value was used to determine statistically significant differences between each sentence type for each age group.

4 | Results

4.1 | Reliability of TECS-E

Our first analysis addressed the reliability of TECS-E as a measure of complex syntax.

4.2 | Internal Consistency of TECS-E

Results indicated that composite reliability was good overall, with a McDonalds omega value of 0.77 across all ages. Reliability was strongest for children between 5 and 6½ years (ω = 0.82 and 0.86, respectively) and weakest for children between 8 and 9 years (ω = 0.6). Based on total mean scores for each item, Cronbach's alpha was 0.924 (SEM 8.789), indicating that the test is internally consistent and that most items are testing the same knowledge. Each family of constructions are also internally consistent with values of α = 0.836 for complement clauses, α = 0.812 for adverbials and α = 0.80 for relative clauses.

4.3 | External Reliability

Test-retest reliability, was examined using a Pearson's product moment correlation coefficient for paired samples, across all age bins: 5;0 (n = 13), 5;6 (n = 14), 6;0 (n = 14), 6;6 (n = 15), 7;0 (n = 48), 8;0 (n = 25) (total n = 129). The estimated paired-sample Pearson's correlation (for all items) was high at r = 0.88 (95% CI 0.83 to 0.91; p = 0.15). The scatter plot of the total percentage of correct items at each time point is shown in Figure S1.

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TABLE 3 | Descriptive statistics derived from the number of correct responses in each section for the full sample ($n = 600$).

		Full sample ($n = 600$) Mean% correct (SD, variance)
Total catch items correct		91.2% (1.49, 2.22)
Total practice items correct		83.6% (1.50, 2.24)
Relative clauses (RC) total correct		86.9% (3.34, 11.15)
	Total RC Subject Intransitive Items Correct	90.4% (1.18, 1.39)
	Total RC Subject Transitive Items Correct	87.7% (1.31, 1.71)
	Total RC Object Relative Items Correct	82.4% (1.50, 2.25)
Complement Clauses (CC) Total Correct		78.9% (5.10, 26.06)
	Total CC with 'wish' Items Correct	83.9% (1.84, 3.40)
	Total CC with 'pretend' Items Correct	83.0% (1.57, 2.45)
	Total CC with 'knows' Items Correct	81.5% (1.39, 1.92)
	Total CC with 'thinks' Items Correct	67.5% (1.57, 2.48)
Adverbial Clauses (AD) Total Correct		75.8% (4.92, 24.21)
	Total AD with 'because' Items Correct	82.6% (1.44, 2.07)
	Total AD with 'before' Items Correct	78.2% (1.61, 2.58)
	Total AD with 'after' Items Correct	71.8% (1.63, 2.66)
	Total AD with 'if' Items Correct	70.6% (1.48, 2.19)
Total trial items correct		80.0% (12.13, 147.16)

An evaluation of agreement in scores across all constructions for the total sample, between each time point, was also conducted using a Bland–Altman analysis (Bland and Altman, 1995). The mean difference was −1.7, and the 95% limits of agreement were −11.5 to 8.2. Visual inspection of the Bland–Altman plot did not reveal any concerning patterns or trends (Figure S3). Analysis within each age bin showed that younger children (bins 5;0 and 5;6) improved more from time 1 to time 2 (mean difference of −3 to −4) than older children (mean difference of less than −1.5 for all other age bins), a one way ANOVA indicated that the difference was not significant [F(1 6556), $p = 0.15$]. Bland–Altman plots for each age bin are provided Figures S3–S9.

We then examined if there was an association between children's performance on the TECS-E and their performance on the TROG-2 (using standard scores for both measures), across all age bins ($n = 129$). The estimated paired-sample Pearson's correlation (for all items) was 0.48 (95% CI 0.33 to 0.60; $p = 0.17$), indicating a moderate correlation between both measures. A scatterplot of standard scores for TECS-E and TROG-2 is available in Figure S10.

4.4 | Children's Overall Understanding of Complex Sentences

In our first research question, we asked how well English-speaking children between 5 and 9 years can understand complex sentences. Table 3 displays the descriptive statistics derived from the number of correct responses in each section for the full sample ($n = 600$). As shown, overall, children performed best on relative clauses, followed by complement clauses and the lowest performance was on adverbial clauses. Results from the full factorial ANOVA indicated that the type of construction had a significant main effect on how children performed [$F(2\,1728) = 55.34$, $p < 0.00001$]. The Fisher LSD post hoc analysis revealed that all three constructions were significantly different ($p < 0.001$) at a 95% confidence level

There is the possibility of response bias when completing a task that requires a yes or no response, whereby the child may always give a 'yes' or 'no' response when they do not understand the construction presented. In order to examine this, we calculated a *d'* prime measure (McNicol, 1972) by averaging the probabilities of true and false positives for all 100 children in each age bin first and then calculating the *d*' based on these averages. We then plotted this against the percentage of correct answers for each type of construction. The plot is available as Figure S2. With no bias, the points fall on the solid line in the plot. Points that are above the line show a bias to answer yes (where children are performing much better on the compatible than the incompatible items), and points below the line indicate no bias (where children are performing much better on the incompatible than the compatible items). Our plot shows no bias for the majority of constructions but a mild *yes* bias for the adverbial clauses, indicating that some children found it slightly easier to answer a compatible adverbial than one that was incompatible.

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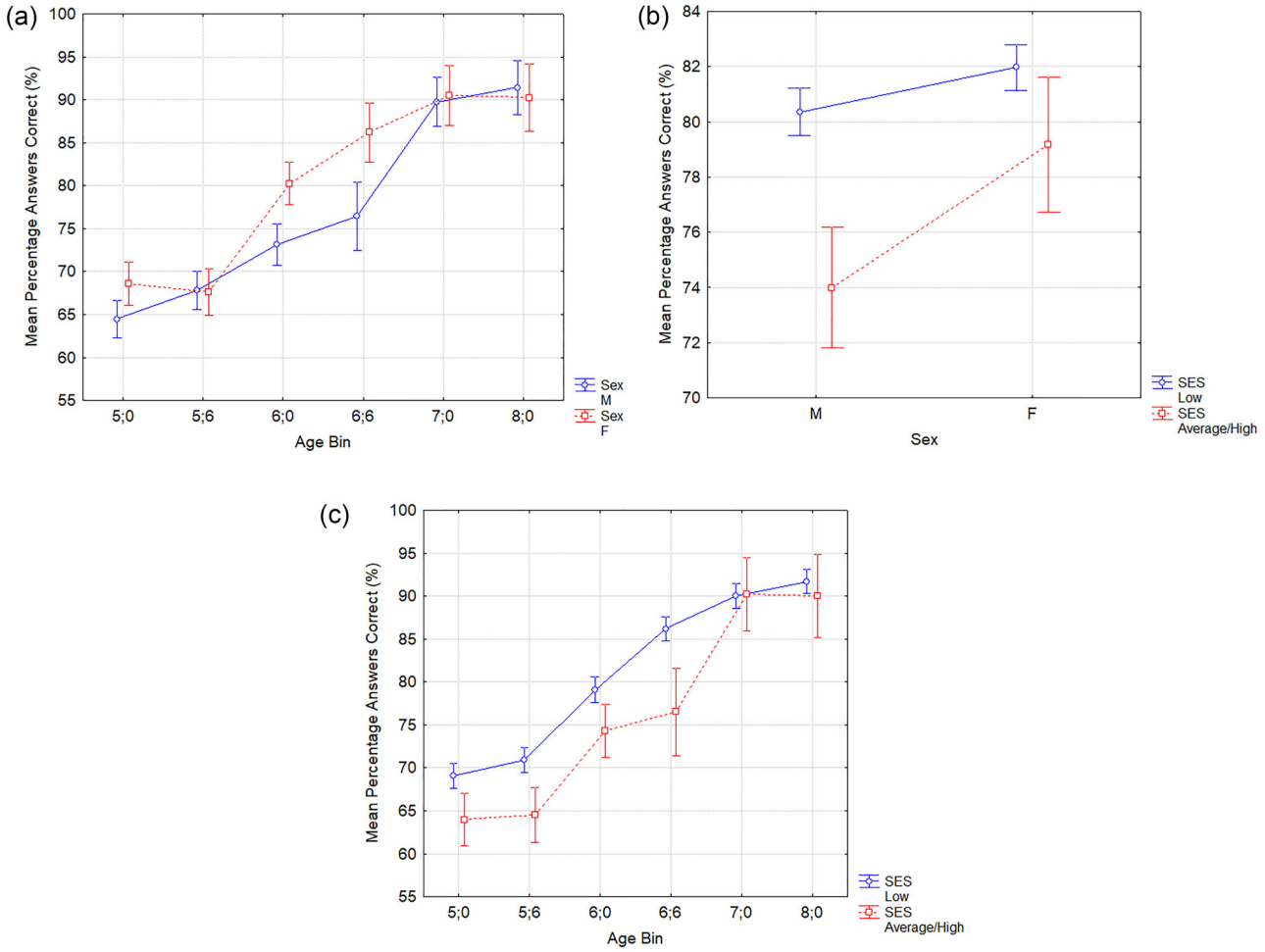


FIGURE 1 | (a) Interaction between age and sex. (b) Interaction between sex and SES. (c) Interaction between SES and age.

In our next research question, we asked to what degree the type of construction, age, sex, or SES impacted children's overall performance. A full factorial ANOVA revealed that all four factors were highly significant in their impact on children's understanding of complex sentences ($p \leq 0.0001$). In keeping with our hypothesis and reflected in Figure 1 a–c, children's performance increased with age [$F\ (5\ 1728) = 101.64$, $p \leq 0.000$]. In addition, children from low SES backgrounds achieved lower scores compared to children from high or average SES backgrounds [$F(1\ 1728) = 26.71$, $p \leq 0.000$], and females performed better than males [$F(1\ 1728) = 14.66$, $p = 0.000$]. Our analysis also identified two significant two way interactions, specifically, an interaction between age and sex [$F(5\ 1728) = 3.738$, $p = 0.002$] (Figure 1a) and an interaction between sex and SES [$F(1\ 1728) = 4.0858$, $p = 0.043$] (Figure 1b). Figure 1a shows how the significant difference in sex is driven by the higher performance of females compared to males between 6 and 7 years of age. Figure 1b shows how the significantly higher performance of females compared to males is more marked in children from low SES backgrounds. Note, the vertical bars indicate the 95% confidence intervals.

Finally, while there was no significant interaction between age and SES at a 95% confidence level [$F(5\ 1728) = 2.0701$, $p = 0.066$], the interaction was significant at a 90% confidence level. Figure 1c shows how the lower performance in children from low socio-economic areas was no longer observed in children after 7 years of age.

4.5 | Understanding of Different Clause Types

In our next research question, we asked about the order of difficulty in the types of sentences understood, within each family of constructions. Children's performance (% correct) across each age bin, for each construction and clause type within, is given in Table S2. Results from the Fisher LSD post-hoc analysis indicated that if the difference between any two sets of scores was larger than 0.358, we should consider it a significant and meaningful difference (at a probability of ≤0.05). Children's performance and differences within each family of constructions are illustrated in the line plots in Figure 2a–c.

As shown in Figure 2a, intransitive subject relatives were the highest scoring relative clauses, followed by transitive subject and lastly object relatives. However, there were no significant differences between subject intransitive and transitive relatives across all ages. Younger children performed significantly lower on object relatives than both types of subject relatives. However, from 6;06 to 7;11 years, these differences were no longer significant. Interestingly, at 8 years, a significant difference re-emerged. The graph also shows how there is little change in children's

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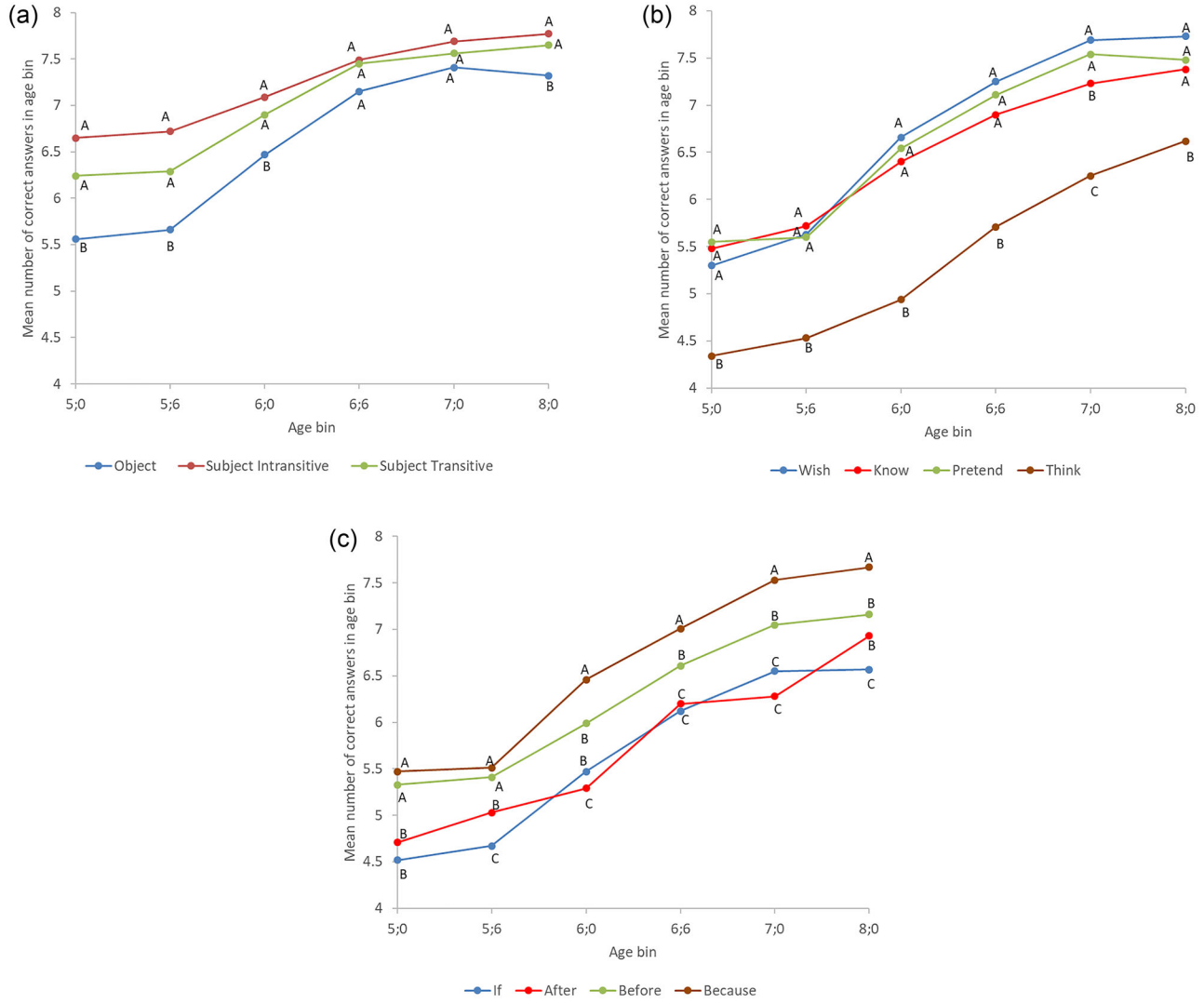


FIGURE 2 | (a) Line plot of children's performance on each type of relative clause per age bin. (b) Line plot of Children's performance on each type of complement clause per bin. (c) Line plot of children's performance on each type of adverbial clause per age bin. At any age point, clause types designated with the same letter do not differ significantly (at a 95% confidence level).

performance across all three types of relative from 5–5;06 years and a steep upward trajectory in children's performance from 5;06 to 6;06 years (particularly for subject transitive and object relatives).

Figure 2b shows how children performed best on constructions using the complement-taking verbs *wish pretend* and *know*, with no significant differences emerging across all but one age bin (children between 7 and 7;11 years). From 5;06 – 6;0 years there is a steep upward curve in children's understanding of these constructions, with a continuing upward trajectory until about 7 years. With respect to *think* constructions we see an upward trajectory from 5 to 8 years, at which point these constructions are still not mastered. Children consistently performed significantly lower on *think* constructions than each of the other complement-taking verbs (including the mental state verb *know*), across all age bins.

Figure 2c shows the upward trajectory in children's performance on the adverbial clauses. Children performed best on *because* clauses, followed by *before* clauses, with lower and overlapping performance on *after* and *if* clauses. Except for the 5 to 5;06-year-olds (where performance was similarly poor), differences in performance were significant between *because* and *before* constructions for all other ages. Significant differences also emerged between *after* and *because* and *before* constructions, and between *If* and *because* and *before* constructions, with children performing consistently lower on the *after* and *if* constructions. Interestingly, while children performed significantly better on *after* than *if* constructions at 5;06 years and again at 7;11 years, their performance was overlapping in the intervening age bins, with no significant differences. It is also interesting to note the steep upward increase in children's understanding of *because* and *if* clauses at 5;06 years.

5 | Discussion

In this study, we examined English-speaking children's understanding of complex syntax between 5 and 9 years. The study is

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unique in that we report on a large dataset examining the three main families of complex syntactic constructions, which account for the majority of multi-clause sentences that English-speaking children hear and produce (Diessel 2004). In addition, we use an assessment tool designed to minimise the processing load for children and constructions that are reflective of what children say and hear in natural discourse.

5.1 | Reliability of TECS-E

Firstly, we aimed to ascertain how reliable the TECS-E is as a measure of complex syntax. McDonalds omega allowed us to examine the strength of association between items as well as item-specific measurement errors and therefore provided realistic estimates of true reliability. While the reliability was good overall (0.77), it was strongest for the younger children (5 and 6 ½ years) (0.82 and 0.86) and weakest for those between 8 and 9 years (0.6). This is likely driven by the fact that older children performed near ceiling on many of the items. In addition, the Cronbach's alpha score of 0.924 reflects a high degree of internal consistency and indicates that most items are testing the same knowledge. The TECS-E is also externally reliable, indicated by a strong Pearson correlation of .88 on test-retest and high levels of agreement shown on a Bland Altman analysis (a non-significant mean difference of -1.7 between the first and second test administration). Finally, to further validate the TECS-E we wanted to establish if there was any association between our measure and an established test of receptive grammar (the TROG-2). Our analysis showed a moderate correlation between both measures. This was in keeping with our hypothesis, as while both tests aim to assess children's grammar, the TROG-2 focuses more on simple sentences (with some relative clauses), and there are few constructions in common across both tests.

5.2 | Overall Impact of Type of Construction, Clause Type and Age

Overall, children performed best on relative clauses, followed by complement clauses, with the lowest performance on adverbial clauses. While this relative clause advantage is in keeping with Frizelle et al. (2018), children's performance on adverbial and complement clauses was not significantly different in this previous study. However, it is noteworthy that the sample size was small (n = 33, and across a narrower age range, mean age 6;06 years) relative to that reported on here.

In keeping with our hypothesis and the developmental literature, children's performance increased with age on each family of constructions, from 77%–95% correct for relative clauses, 65%–91% correct for complement clauses and 63%–89% correct for adverbial clauses. Interestingly, across each family of constructions, we see little change between 5 and 5;06 years. For relative clauses, there is a steep upward trajectory from 5;06 to 6;06 and a more gradual growth to 7 years. For adverbial and complement constructions, the steep upward trajectory is longer and continues to 7 years with minimal growth beyond that for most clause types within. *Think* and *after* constructions are two exceptions.

5.3 | Relative Clauses

Broadly speaking our findings are in keeping with previous literature showing that although children are performing above chance on relative clauses at 5 years (de Villiers et al. 1979; Sheldon 1974; Tavakolian, 1981), they have not yet reached full mastery on subject and object relatives until closer to 6 ½ years. Although there are no significant differences between children's performance on both types of subject relative, we can see that the younger children perform consistently better on intransitive subject relatives. Our data also indicate that younger children (those under 6½ years) performed significantly lower on object relatives than both transitive and intransitive subject relatives. Recall that all object relatives included here are discourse relevant (have an inanimate head noun and a pronominal subject). Our findings are in keeping with previous literature indicating a subject relative advantage (Diessel and Tomasello 2005; Frizelle et al. 2019a), and the theory that canonical word order is easier for young children to process. Our data also contradict the premise that by assessing children between 5 and 6 ½ years using discourse relevant object relatives, we can mitigate against the processing load incurred by their non-canonical word order. In contrast to our findings, Kidd et al. (2007) reported no asymmetry between subject relatives and this frequently heard subtype of object relative, among 3–4-year-old children on a sentence repetition task. Our contradictory findings may be accounted for by task differences. While our assessment task is designed to minimise processing load, previous literature suggests that sentence recall, in which working memory is supported by production, may be an easier task than one of pure comprehension (Frizelle et al. 2017). It may also be the case that our minimal task processing requirements also enhanced children's performance on the subject relatives, thereby revealing a discrepancy between these two relative clause types. In keeping with findings by Frizelle and Fletcher (2014), our data indicate children over 6½ showed no significant differences in their understanding of subject and object relatives. Therefore, when using pure comprehension tasks, it may be that children need to be older to take full advantage of these more frequently heard discourse-relevant object relatives.

5.4 | Complement Clauses

With respect to complement clauses, we see a steep growth in children's understanding of these constructions from 5 ½–6 years, continuing until about 7 years.

Our data indicate no significant differences in children's understanding of constructions with the verbs *wish, pretend* and *know*. Children performed significantly lower on the mental verb *think* across all ages and did not show complete mastery even up to 8;11 years. The differential between children's understanding of the mental verbs *think* versus *know* may be reflective of how these verbs are used semantically in the linguistic input. While *think* and *know* can have several semantic senses, *know* is usually used to indicate certainty (*I know that it is cloudy outside*) and *think* typically describes a degree of uncertainty (*I think that it is raining outside*). However, *think* is also used as a 'comment clause' to indicate certainty (*I think that it is time for your nap*) (Manson 1995). Distinguishing between these two semantic senses may be challenging for young children. Howard

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et al. (2008) found that over half of the phrases that included the verb *think*, used in the input to 3- and 4-year-olds, were used to express certainty rather than uncertainty. This input does not support children's understanding of the semantics of the mental verb *think* and the complement-clause constructions in which it is used (Howard et al., 2008). Consequently, children have not achieved full mastery of think clauses until 9 years and beyond.

5.5 | Adverbial Clauses

Within adverbial clauses, there is again a sharp growth in children's understanding of 3 of the 4 adverbial constructions (*if, before* and *because*) between 5½ and 6 years. With respect to age of acquisition, our findings are in keeping with Amidon (1976), who found significant growth between the ages of 5 and 7 across all 4 adverbials examined here and Emerson and Gekoski (1980), who found that children were closer to 8 years when they mastered *because* and *if* sentences. However, our findings contrast with those of De Ruiter et al. (2018) who reported above chance performance for *because* and *if* constructions at 5 years ($n = 34$) and Blything et al. (2015) who reported above chance understanding in 3–4 year old children ($n = 22$) for *before* and *after* constructions. Differences in children's performance are likely related to different testing methodologies as well as sample size. For example, in Blything et al. (2015) children were presented with two animations sequentially, along with a sentence containing the connective before or after, *He poured the ketchup before he ate the burger* and were then asked to *touch the thing that Tom/Sue did first*, while supported by a freeze frame of both actions. In this scenario, one could argue that children could respond correctly on the basis of understanding the concept of *first*, without a full understanding of *before* or *after*.

Our data showed that children's highest performance was on the *because* clauses, followed by *before* clauses, with significantly lower overlapping performance on *after* and *if* clauses. Our finding that *because* clauses were the easiest type of adverbial construction contrasts with De Ruiter et al. (2018), who reported a lower performance on both *because* and *if* relative to *before* and *after* clauses. In our paradigm, sentences are designed to reflect causal events that could happen in the real world, are plausible and therefore children's understanding is not muddied by the likelihood of a particular event happening or not (e.g., *The boy cut his leg because he climbed the tree*). In contrast, causal constructions in the De Ruiter task were designed to be swapped with *if* constructions and therefore may not always have presented as plausible or likely to young children, for example, *She feels really warm, because she dives in the pool* (one might consider her more likely to dive in the pool because she feels really warm).

Our reported hierarchy (because, before, after/if), particularly with respect to *if* is difficult to explain. Given that *because* and *if* are more frequent than *after* and *before* sentences (Diessel 2001; De Ruiter et al. 2017), our data suggests that the frequency of specific structural types is not sufficient to account for this pattern of *if-clause* development. It is also the case that children start producing *because* and *if* sentences before they start producing *after* and *before* sentences (Diessel 2004), suggesting that they find *because-* and *if*-sentences easier. Again, this does not account for children's lower *if*-clause performance. With respect to semantic complexity, both *because* and *if* sentences are similar in that they require an understanding of temporality and causality. Therefore, applying a semantic complexity account does not allow us to tease apart the reasons for children's much lower performance on *if*-clauses. One premise put forward by De Ruiter et al. (2018) is that children may be less familiar with *if* clauses being used to represent physical causality. They cite work by Ford and Thompson (1986), highlighting that in everyday conversation speakers often use *if* clauses to provide a conceptual framework for a larger chunk of discourse and not just the main clause within the complex sentence *(e.g., 'If I ever win the lottery, I have plenty ideas of what to do with the money.') p. 215.*

Our finding that children performed significantly better on *before* adverbials than *after*, would seem best explained by a combination of factors. Data from Leech et al. (2014) indicate that while *before* is used 1½ times more often in other constructions than as a temporal connective in complex sentences, *after* is used 4 times more often in other constructions in child-directed speech (De Ruiter et al. 2017). In addition, when used in other constructions *before* is always used either spatially (e.g., *the dogs ran before and behind*) or temporally, and this consistency results in less ambiguity for children trying to process a given *before* construction. In contrast, *after* is semantically less transparent and is also used in verbal phrases such as 'to take after', 'to ask after' or 'to look after', making it more difficult for children to parse 'online'.

5.6 | Overall Impact of Sex and Socioeconomic Status

In keeping with our hypothesis, children from socially disadvantaged backgrounds performed significantly lower on all clause types than their more advantaged peers. Our findings align with Huttenlocher et al. (2002), who also reported significantly poorer understanding of complex sentences in children living in social disadvantage compared to those who were not. Huttenlocher and colleagues also noted how syntactic input affected children's complex language skill levels and reported greatest syntactic growth in preschool classes where teachers' language was more syntactically complex. Interestingly, our data indicates that by 7 years the effect of SES was no longer evident. In keeping with Huttenlocher, syntactic input from teachers in school is a likely factor in reducing these effects. In addition, this is a significant stage in emerging literacy, where children are increasingly starting to read themselves and are consequently exposed to more complex syntax.

Our data also indicated that girls performed significantly better than boys. This difference appeared to be driven by the higher performance of girls compared to boys between 6 and 7 years of age, suggesting a faster rate of syntactic development in females in this age range. We also note that the lower performance of boys compared to girls is more marked in children from disadvantaged backgrounds. Our findings in relation to the interaction between sex differences and age are aligned with Etchell et al. (2018) and Lange et al. (2016), who also noted a decrease in differences as children get older. Finally, the interaction between sex and SES is not unexpected. Given that both boys and children living in social disadvantage are more likely to be identified as at risk for language disorder (Norbury et al., 2016; McKean et al. 2018),

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it is not surprising that they show a slower rate of complex syntactic development up to around 7 years. In addition, due to a complex interplay of biological, sociocultural, and psychological influences, social and environmental factors affect boys and girls differently, which can lead to differences in language outcomes. For example, teachers have rated the classroom behaviour of boys living in social disadvantage to be more disruptive than girls, while parents had lower expectations of boys than girls in relation to overall school performance (Entwisle et al. 2007).

6 | Conclusion

This is the first study to report on a large sample of English-speaking children's understanding, specifically of complex syntactic structures, between 5 and 9 years. While the TECS-E does not include less prototypical examples of complex syntactic structures (such as although adverbials or whose relatives), those included account for the majority of multi-clause sentences that English-speaking children hear and produce. The TECS-E was designed to be used independently, to reflect how children process language in everyday interactions, and to include constructions that follow the linguistic patterns of those that children say and hear in natural discourse. The TECS-E was found to be both internally and externally reliable. Children's understanding of all constructions increased with age, with considerable growth in development between 5;06 and 7 years, suggesting that 7 years is an important milestone in children's understanding of complex syntax. This is further supported by the fact that the lower performance of boys (versus girls) and children living in social disadvantage (versus those who were more affluent) was no longer observed after 7 years.

This study furnishes a reference dataset of the growth in typically developing children's understanding of complex sentences, indicating their most likely developmental journey in the early school years, through mastery of individual structures. In addition, the dataset provides a guide for clinicians regarding when they might expect differences between boys' and girls' understanding of complex sentences to resolve, as well as an approximate age at which children living in social disadvantage perform comparably to their more affluent peers. The information can be used by clinicians to identify gaps in understanding and to guide the design and delivery of syntactic interventions.

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Ethics Statement

Ethical approval was granted for the study through the Social Research Ethics Committee, University College Cork (2020-123).

Conflicts of Interest

The authors declare no financial or conflict of interest.

Data Availability Statement

The data that support the findings will be available in OSF at https://osf.io/gv9dj/ following an embargo from the date of publication to allow for commercialisation of research findings.

Endnote

[1]The Pobal Deprivation Index uses two main dimensions to determine the SES status of a given area. 1. *Relative Deprivation* which includes unemployment rate, social class composition, dependency ratio and income levels and 2. Affluence, which includes educational attainment, occupation status and household type. Factors are combined to produce a composite score.

References

Adani, S., and M. Cepanec. 2019. "Sex Differences in Early Communication Development: Behavioral and Neurobiological Indicators of More Vulnerable Communication System Development in Boys." *Croatian Medical Journal* 60, no. 2: 141–149. https://doi.org/10.3325/cmj.2019.60.141.

Amidon, A. 1976. "Children's Understanding of Sentences With Contingent Relations: Why Are Temporal and Conditional Connectives so Difficult?" *Journal of Experimental Child Psychology* 22, no. 3: 423–437. https://doi.org/10.1016/0022-0965(76)90106-5.

Amidon, A., and P. Carey. 1972. "Why Five-Year-Olds Cannot Understand Before and After." *Journal of Verbal Learning and Verbal Behavior* 11, no. 4: 417–423. https://doi.org/10.1016/S0022-5371(72)80022-7.

Balthazar, C. H., and C. M. Scott. 2024. "Sentences Are Key: Helping School-Age Children and Adolescents Build Sentence Skills Needed for Real Language." *American Journal of Speech-Language Pathology* 33, no. 2: 564–579.

Berman, R. A. 2009. "Development of the Language of Thought and Its Relation to the Acquisition of Verbs." In *The Development of Language*, edited by L. Naigles and M. Tomasello, 139–163. Psychology Press.

Berman, R. A., and B. Nir-Sagiv. 2009. "Clause Packaging in Narratives: A Crosslinguistic Developmental study." In *Crosslinguistic Approaches to the Psychology of Language: Research in the Tradition of Dan Isaac Slobin*, edited by J. Guo, E. Lieven, N. Budwig, S. Ervin-Tripp K. Nakamura, and S. Ozcaliskan, 149–162. Psychology Press.

Bishop, D. V. M. 2003. *Test for Reception of Grammar [Measurement Instrument]*. Pearson.

Bland, J. M., and D. G. Altman 1995. "Calculating Correlation Coefficients With Repeated Observations: Part 2 – Correlation Between Subjects." *BMJ* 310, no. 6980: 633. https://doi.org/10.1136/bmj.310.6980.633.

Bloom, L., J. Tackeff, and M. Lahey. 1984. "Learning to in Complement Constructions." *Journal of Child Language* 11: 391–406.

Bloom, L., M. Rispoli, B. Gartner, and J. Hafitz 1989. "Acquisition of Complementation." *Journal of Child Language* 16, no. 1: 101–120.

Blything, L. P., and K. Cain. 2016. "Children's Processing and Comprehension of Complex Sentences Containing Temporal Connectives: The Influence of Memory on the Time Course of Accurate Responses." *Developmental Psychology* 52, no. 10: 1517–1529. https://doi.org/10.1037/dev0000201.

Blything, L. P., R. Davies, and K. Cain. 2015. "Young Children's Comprehension of Temporal Relations in Complex Sentences: The Influence of Memory on Performance." *Child Development* 86, no. 6: 1922–1934.

Brandt, S., D. Buttelmann, E. Lieven, and M. Tomasello. 2016. "Children's Understanding of First- and Third-Person Perspectives in Complement Clauses and False-Belief Tasks." *Journal of Experimental Child Psychology* 151: 131–143. https://doi.org/10.1016/j.jecp.2016.03.004.

Cain, K., N. Patson, and L. Andrews. 2005. "Age- and Ability-Related Differences in Young Readers' Use of Conjunctions." *Journal of Child Language* 32: 877–892. https://doi.org/10.1017/S0305000905007014.

14606984, 2025, 4, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1460-6984.70079 by Hse Research & Development, Wiley Online Library on [12/08/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Carpenter M., K. Nagell, M. Tomasello, G. Butterworth, and C. Moore. 1998. "Social Cognition, Joint Attention, and Communicative Competence From 9 to 15 Months of Age." *Monographs for the Society of Research in Child Development* 63, no. 4:1–143. https://doi.org/10.2307/1166214.

Central Statistics Office. n.d. "Census 2016 reports. Central Statistics Office website." Retrieved December 1, 2021. https://www.cso.ie/en/census/census2016reports/.

Cheung, H., H. Chen, and W. Yeung. 2009. "Relations Between Mental Verb and False Belief Understanding in Cantonese-Speaking Children." *Journal of Experimental Child Psychology* 104: 141–155. https://doi.org/10.1016/j.jecp.2009.05.004.

Clark, E. V. 1971. "On the Acquisition of the Meaning of "Before" and "After"." *Journal of Verbal Learning and Verbal Behavior* 10: 266–227.

De Ruiter, L. E., H. C. P. Lemen, E. V. M. Lieven, S. Brandt, and A. L. Theakston. 2021. "Structural and Interactional Aspects of Adverbial Sentences in English Mother-child Interactions: An Analysis of Two Dense Corpora." *Journal of Child Language* 48, no. 6: 1150–1184. https://doi.org/10.1017/s0305000920000641.

De Ruiter, L. E., A. L. Theakston, S. Brandt, and E. V. M. Lieven. 2017. "The Relationship Between Parental Input and Children's Spontaneous Use of Adverbial Clauses Containing After, Before, Because, and If." Poster Presented at the 14th International Congress for the Study of Child Language (IASCL), July 17–21.

De Ruiter, L. E., A. L. Theakston, S. Brandt, and E. V. M. Lieven. 2018. "Iconicity Affects Children's Comprehension of Complex Sentences: The Role of Semantics, Clause Order, Input and Individual Differences." *Cognition* 171: 202–224.

Diessel, H. 2001. "The Ordering Distribution of Main and Adverbial Clauses: A Typological Study." *Language* 77: 343–365.

Diessel, H. 2004. *The Acquisition of Complex Sentences*. Cambridge University Press.

Diessel, H. 2005. "Competing Motivations for the Ordering of Main and Adverbial Clauses." *Linguistics* 43, no. 3: 449–470. https://doi.org/10.1515/ling.2005.43.3.449.

Diessel, H., and M. Tomasello 2000. "The Development of Relative Clauses in Spontaneous Child Speech." *Cognitive Linguistics* 11, no. 1–2: 131–151. https://doi.org/10.1515/cogl.2001.006.

Diessel, H., and M. Tomasello 2001. "The Acquisition of Finite Complement Clauses in English: A Corpus-based Analysis." *Cognitive Linguistics* 12, no. 2: 97–142. https://doi.org/10.1515/cogl.12.2.97.

Diessel, H., and M. Tomasello. 2005. "A New Look at the Acquisition of Relative Clauses." *Language* 81: 1–25 https://doi.org/10.1353/lan.2005.0169.

Dollaghan, C. A., T. F. Campbell, J. L. Paradise, et al. 1999. "Maternal Education and Measures of Early Speech and Language." *Journal of Speech, Language, and Hearing Research* 42, no. 6: 1432–1443.

Emerson, H. F., and W. L. Gekoski. 1980. "Development of Comprehension of Sentences With "Because" or "If"." *Journal of Experimental Child Psychology* 29, no. 2: 202–224. https://doi.org/10.1016/0022-0965(80)90016-8.

Entwisle, D. R., K. L. Alexander, and L. S. Olson. 2007. "Early Schooling: The Handicap of Being Poor and Male." *Sociology of Education* 80, no. 2: 114–138. https://doi.org/10.1177/003804070708000202.

Etchell A., A. Adhikari, L. S. Weinberg, et al. 2018. "A Systematic Literature Review of Sex Differences in Childhood Language and Brain Development." *Neuropsychologia*. 114: 19–31. https://doi.org/10.1016/j.neuropsychologia.2018.04.01.

Ford, C. E., and S. A. Thompson. 1986. "Conditionals in discourse: A text based study from English." In *On conditionals*, edited by E. C. Traugott, A. ter Meulen, J. D. A. Snitzer Reilly, and C. A. Ferguson, 353–372. Cambridge University Press.

Frazier, L. 1987. "Syntactic Processing: Evidence From Dutch." *Natural Language & Linguistic Theory* 5, no. 4: 519–559.

French, L. A., and A. L. Brown. 1977. "Comprehension of "Before" and "After" in Logical and Arbitrary Sequences." *Journal of Child Language* 4, no. 2: 247–256. https://doi.org/10.1017/S0305000900001641.

French L. A., and K. Nelson. 1985. *Young Children's Knowledge of Relational Terms: Some Ifs, Ands, and Buts*. Springer-Verlag.

Frizelle, P., A. Buckley, T. Biancone, et al. 2024. "How Reliable Is Assessment of Children's Sentence Comprehension Using a Self-Directed App? A Comparison of Supported versus Independent Use." *Journal of Child Language* 51, no. 6: 1395–1423. https://doi.org/10.1017/s0305000923000545.

Frizelle, P., and P. Fletcher. 2014. "Relative Clause Constructions in Children With Specific Language Impairment." *International Journal of Language & Communication Disorders* 49, no. 2: 255–264. https://doi.org/10.1111/1460-6984.12070.

Frizelle, P., C. O'Neill, and D. V. M. Bishop. 2017. "Assessing Understanding of Relative Clauses: A Comparison of Multiple-Choice Comprehension Versus Sentence Repetition." *Journal of Child Language* 44, no. 6: 1435–1457. https://doi.org/10.1017/s0305000916000635.

Frizelle, P., P. Thompson, M. Duta, and D. V. M. Bishop. 2019a. "Assessing Children's Understanding of Complex Syntax: A Comparison of Two Methods." *Language Learning* 69, no. 2: 255–291. http://doi.org/10.1111/lang.12332.

Frizelle, P., P. A. Thompson, M. Duta, and D. V. M. Bishop. 2019b. "The Understanding of Complex Syntax in Children With Down Syndrome." *Wellcome Open Research* 3: 140. https://doi.org/10.12688/wellcomeopenres.14861.2.

Frizelle, P., P. A. Thompson, D. McDonald, and D. V. M. Bishop. 2018. "Growth in Syntactic Complexity Between Four Years and Adulthood: Evidence From a Narrative Task." *Journal of Child Language* 45, no. 5: 1174–1197. https://doi.org/10.1017/s0305000918000144.

Frizelle, P., P. A. Thompson, M. Duta, and D. V. M. Bishop 2019a. "Assessing Children's Understanding of Complex Syntax: a Comparison of Two Methods." *Language Learning* 69, no. 2: 255–291. https://doi.org/10.1111/lang.12332.

Gorrell, P., S. Crain, and J. D. Fodor. 1989. "Contextual Information and Temporal Terms." *Journal of Child Language* 16, no. 3: 623–632. https://doi.org/10.1017/S0305000900010758.

Guo, L. Y., P. Schneider, and W. Harrison. 2021. "Clausal Density Between Ages 4 and 9 Years for the Edmonton Narrative Norms Instrument: Reference Data and Psychometric Properties." *Language, Speech, and Hearing Services in Schools* 52, no. 1: 354–368. https://doi.org/10.1044/2020_LSHSS-20-00043.

He, W., N. Xu, and R. Ji. 2017. "Effects of Age and Location in Chinese Relative Clauses Processing." *Journal of Psycholinguistic Research* 46, no. 5: 1067–1086.

Hoff, E. 2006. "How Social Contexts Support and Shape Language Development." *Developmental Review* 26, no. 1: 55–88.

Howard, A. A., L. Mayeux, and L. R. Naigles 2008. "Conversational Correlates of Children's Acquisition of Mental Verbs and a Theory of Mind." *First Language* 28, no. 4: 375–402. https://doi.org/10.1177/0142723708091044.

Huddleston, R., G. K. Pullum, and L. Bauer. 2002. *The Cambridge Grammar of the English Language*. Cambridge University Press.

Huttenlocher, J., M. Vasilyeva, E. Cymerman, and S. Levine. 2002. "Language Input and Child Syntax." *Cognitive Psychology* 45, no. 3: 337–374.

Huttenlocher, J., H. Waterfall, M. Vasilyeva, J. Vevea, and L. V. Hedges. 2010. "Sources of Variability in Children's Language Growth." *Cognitive Psychology* 61, no. 4: 343–365. https://doi.org/10.1016/j.cogpsych.2010.08.002.

14606984, 2025, 4, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1460-6984.70079 by Hse Research & Development, Wiley Online Library on [12/08/2025]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Jiang, H., J. A. Logan, and R. Jia. 2018. "Modeling the Nature of Grammar and Vocabulary Trajectories From Prekindergarten to Third Grade." *Journal of Speech, Language and Hearing Research* 61, no. 4: 910–923. https://doi.org/10.1044/2018_JSLHR-L-17-0090.

Johnson, H. L. 1975. "The Meaning of Before and After for Preschool Children." *Journal of Experimental Child Psychology* 19, no. 1: 88–99. https://doi.org/10.1016/0022-0965(75)90151-4.

Kidd, E., S. Brandt, E. Lieven, and M. Tomasello. 2007. "Object Relatives Made Easy: A Cross-Linguistic Comparison of the Constraints Influencing Young Children's Processing of Relative Clauses." *Language and Cognitive Processes* 22, no. 6: 860–897.

Kidd, E., E. Lieven, and M. Tomasello. 2006. "Examining the Role of Lexical Frequency in the Acquisition and Processing of Sentential Complements." *Cognitive Development* 21, no. 2: 93–107.

Kovačević, M., J. Kraljević, and M. Cepanec 2007. "Sex Differences in Lexical and Grammatical Development in Croatian." In *Proceedings from the First European Network Meeting on the Communicative Development Inventories* edited by M. Kopić and G. M. Gaskell, 5–15. Gävle University Press.

Kuhn, D., and H. Phelps. 1976. "The Development of Children's Comprehension of Causal Direction." *Child Development* 47, no. 1: 248–251. https://doi.org/10.2307/1128307.

Lange, B. P., H. A. Euler, and E. Zaretsky. 2016. "Sex Differences in Language Competence of 3- to 6-year-old Children." *Applied Psycholinguistics* 37, no. 6: 1417–1438. https://doi.org/10.1017/S0142716415000624.

Leech, G., P. Rayson, and A. Wilson. 2014. *Word Frequencies in Written and Spoken English: Based on the British National Corpus*. Routledge.

Levine, D., A. Pace, R. Luo, et al. 2020. "Evaluating Socioeconomic Gaps in Preschoolers' Vocabulary, Syntax and Language Process Skills With the Quick Interactive Language Screener (QUILS)." *Early Childhood Research Quarterly* 50: 114–128. https://doi.org/10.1016/j.ecresq.2018.11.006.

Manson, N. 1995. "What Does Language Tell Us About Consciousness? First-Person Mental Discourse and Higher-Order Thought Theories of Consciousness." *Philosophical Psychology* 15: 221–238.

McDowell K. D., C. J. Lonigan, and H. Goldstein. 2007. "Relations Among Socioeconomic Status, Age, and Predictors of Phonological Awareness." *Journal of Speech, Language & Hearing Research* 50: 1079–1092. 10.1044/1092-4388(2007/075).

Mckean, C., S. Reilly, A. Morgan, and J. Law. 2018. "Developmental Language Disorder." In *Oxford Handbook of Psycholinguistics*, edited by S. Rueschemeyer and G. M. Gaskell, 2nd ed. Oxford University Press.

McNicol, D. 1972. *A Primer of Signal Detection Theory*. George Allen & Unwin Ltd.

Morton, I., and C. M. Schuele. 2021. "Preschoolers' Imitation of Sentential Complement Sentences: Does the Nature of the Matrix Clause Matter?" *First Language* 41, no. 5: 623–645. https://doi.org/10.1177/01427237211024221.

Norbury, C. F., D. Gooch, C. Wray, et al. 2016. "The Impact of Nonverbal Ability on Prevalence and Clinical Presentation of Language Disorder: Evidence From a Population Study." *Journal of Child Psychology and Psychiatry, and Allied Disciplines* 57, no. 11: 1247–1257. https://doi.org/10.1111/jcpp.12573.

Owen Van Horne, A. J., and S. Lin. 2011. "Cognitive State Verbs and Complement Clauses in Children With SLI and Their Typically Developing Peers." *Clinical Linguistics & Phonetics* 25, no. 10: 881–898. https://doi.org/10.3109/02699206.2011.582226.

Owens, R. E., S. L. Pavelko, and D. Hahs-Vaughn. 2024. "Growth of Complex Syntax: Coordinate and Subordinate Clause Use in Elementary School–Aged Children." *Language, Speech, and Hearing Services in Schools* 55, no. 3: 714–723. https://doi.org/10.1044/2024_lshss-23-00102.

Ozçalişkan, S., and S. Goldin-Meadow. 2010. "Sex Differences in Language First Appear in Gesture." *Developmental Science* 13, no. 5: 752–760. https://doi.org/10.1111/j.1467-7687.2009.00933.x.

Pan B. A., M. L. Rowe, J. D. Singer, and C. E. Snow. 2005. "Maternal Correlates of Growth in Toddler Vocabulary Production in Low-Income Families." *Child Development* 76: 763–782.

Paul, R. 1981. "Analyzing Complex Sentence development." In *Assessing Language Production in Children: Experimental Procedures*, edited by J. Miller, 36–40. University Park Press.

Perner, J., M. Sprung, P. Zauner, and H. Haider. 2003. "Want That Is Understood Well Before Say That, Think That, and False Belief: A Test of de Villiers's Linguistic Determinism on German-Speaking Children." *Child Development* 74, no. 1: 179–188. https://doi.org/10.1111/1467-8624.t01-1-00529.

Piaget, J. 1951. *Play, Dreams and Imitation in Childhood*. Norton & Company.

Pobal. 2016. *Pobal HP Deprivation Indices* [Map]. Pobal. https://data.pobal.ie/portal/apps/experiencebuilder/experience/?id=3b0acba7eb694ffa85340a60f81d516c.

Pyykkonen, P., and J. Jarvikivi. 2012. "Children and Situation Models of Multiple Events." *Developmental Psychology* 48: 521–529. https://doi.org/10.1037/a0025526.

Quirk, R., S. Greenbaum, G. Leech, and J. Svartvik. 1985. *A Comprehensive Grammar of the English Language*. Longman.

Schriefers, H., A. D. Friederici, and K. Kuhn. 1995. "The Processing of Locally Ambiguous Relative Clauses in German." *Journal of Memory and Language* 34, *no*. 4: 499–520.

Sheldon, A. 1974. "The Role of Parallel Function in the Acquisition of Relative Clauses in English." *Journal of Verbal Learning and Verbal Behavior* 13: 272–281. http://doi.org/10.1016/S0022-5371(74)80064-2.

StatSoft, Inc. 2005. *Statistica (Version 7.1)*. StatSoft, Inc.

Suzuki, T. 2011. "A Case-Marking Cue for Filler-Gap Dependencies in Children's Relative Clauses in Japanese." *Journal of Child Language* 38, no. 5: 1084.

Tavakolian, S. L. 1981. "The Conjoined Clause Analysis of Relative clauses." In *Language acquisition and linguistic theory*, edited by S. L. Tavakolian, 167–187. MIT Press.

Vasilyeva, M., H. Waterfall, and J. Huttenlocher. 2008. "Emergence of Syntax: Commonalities and Differences Across Children." *Developmental Science* 11, no. 1: 84–97. https://doi.org/10.1111/j.1467-7687.2007.00656.x.

de Villiers, J. G., and J. E. Pyers. 2002. "Complements to Cognition: A Longitudinal Study of the Relationship Between Complex Syntax and False-Belief-Understanding." *Cognitive Development* 17, no. 1: 1037–1060. https://doi.org/10.1016/s0885-2014(02)00073-4.

de Villiers, J. G., H. Tager-Flusberg, K. Hakuta, and M. Cohen. 1979. "Children's Comprehension of Relative Clauses." *Journal of Psycholinguistic Research* 8: 499–518.

Westerveld, M. F., and K. Vidler. 2016. "Spoken Language Samples of Australian Children in Conversation, Narration and Exposition." *International Journal of Speech-Language Pathology* 18, no. 3: 288–298. https://doi.org/10.3109/17549507.2016.1159332.

Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Table 1. Example of types of sentences discussed. **Table 2**. Children's Performance for Each Family of Constructions and Each Clause Type Within **Figure 1**: Scatter plot of total percentage of correct items at each time point **Figure 2**: Plot of d Prime Measure Against the Proportion of Correct Answers **Figure 3**: Bland-Altman Plot of Agreement for

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Percentage of Total Trial Items Correct at **Figure 4**: Bland-Altman plot for children 5 - 5;05 years **Figure 5**: Bland-Altman plot for children 5;06 - 5;11 years **Figure 6**: Bland-Altman plot for children 6 - 6;05 years **Figure 7**: Bland-Altman plot for children 6;06 - 6;11 years **Figure 8**: Bland-Altman plot for children 7 - 7;11 years **Figure 9**: Bland-Altman plot for children 8 - 8;11 years **Figure 10**: Scatterplot of standard scores for TECS-E and TROG-2

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