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What can conditional sentence grammar acquisition tell us about modularization of development?

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Abstract

This longitudinal study investigated the acquisition of conditional sentences, Type III, which are complex counterfactual constructs, and its relation to short-term and working memory and literacy. One hundred twenty-eight children were tested biannually from UK school Year 1 (aged 5) to Year 4 and then in Year 6 (age 10-11). Conditional sentence acquisition was tested using a sentence repetition test which gives a measure of the internalization of the construct. Other measured factors included grammar comprehension in general, non-verbal intelligence, verbal and visuo-spatial short-term memory (STM), working memory and reading. Verbal STM significantly contributed to acquisition of complex conditionals. Conditional sentence acquisition significantly predicted reading performance, independently of non-verbal intelligence, verbal STM and general grammar development. The findings demonstrate the inter-relatedness of higher cognitive functions during development; modularity in its strictest sense (informational encapsulation, functional isolation) is not present in normally developing brains. Also, important educational applications are discussed.

Keywords grammar acquisition, conditional sentences, reading, short-term memory, sentence processing

1. Introduction

Research on language development has shown that by the age of five years the majority of typically-developing children have acquired fluent speech that is mostly grammatically correct. However, the grammatical content of this language is relatively simple. Investigation of the later acquisition of grammar has shown that there is considerable variability among school-aged children (Loban, 1976; Scott, 1984) in their use of more complex structures such as expanded noun phrases, prepositional phrases, and dependent clauses. This later stage of grammar acquisition might provide us with a richer understanding of the process of internalizing the language's grammar.

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It was proposed by Ullman (2001) that under normal circumstances, a young child acquires grammatical rules of their first language implicitly while vocabulary is acquired explicitly. Research using various methods including patient studies (Ullman, 2001), imaging (Friederici, 2011), and syntactic priming (Branigan, 2007) has demonstrated the existence of grammatical representations in the brain, which are separate from other aspects of language. It is quite a prevalent view, supported by research (e.g., Kidd, 2012; Kidd & Arciuli, 2016), that grammatical representations are formed through statistical learning, i.e., extraction of regularities from input. However, there is still a lot about the process that is not understood. It has been argued that the process of grammatical acquisition occurs independently of other aspects of development; for example, it is not influenced by general reasoning ability (Rice, Wexler & Hershberger, 1998). This view perhaps stems from the observation that early grammar acquisition seems to follow defined stages and does not seem to require any explicit instruction or correction (Brown & Hanlon, 1970). However, a recently popular neuroconstructivist theory (Karmiloff-Smith, 1994; Westermann et al., 2007; Westermann, 2016), which provides a compromise between the strict domain-general and domain-specific (modular) views of cognition would lead one to predict that the process of grammar acquisition is not so isolated. According to the neuroconstructivist hypothesis the specification of different brain systems occurs through the process of development. Thus since there is less specification in the early stages of development one would expect that different systems could influence each other. In early primary school years not only the acquisition of grammar is incomplete, but many other important developments are taking place, such as changes in children's logic and reasoning ability and the increasing capacity of short-term and continued development of working memory (WM). Working memory is conceptualized as a limited capacity memory system capable of simultaneously storing and manipulating information in the service of accomplishing a task (e.g., Baddeley, 2003). The storing of information for short periods of time is often referred to as short-term memory (STM). It is the manipulation of information online aspect that is consensually emphasized when talking about WM, but STM is the necessary prerequisite for this function.

In early primary school years children are also learning new skills, in particular reading and arithmetic. These skills are not a product of biological evolution. Yet it has been shown that there are areas in adult brains which are allocated specifically to those skills (Amalric & Dehaene, 2016; Nobre, Allison & McCarthy, 1994; Petersen, Fox, Snyder & Raichle, 1990; Shum et al., 2013). It is hypothesized that specialization to accommodate those skills is formed during development. Studies have demonstrated that the acquisition of those skills does not occur in isolation from other aspects of development. For example, grammar acquisition in general is predictive of literacy performance (Nation, Clarke, Marshall & Durand, 2004; Rego & Bryant, 1993). However, there is little research on the relationship between acquisition of specific types of grammatical constructions in typically-developing children and literacy. The current project follows up the acquisition of one specific complex grammatical construction and explores whether it was influenced by domain-general processes of STM and WM and whether it, in turn, influences children's learning to read.

The complex grammatical construction under investigation is type III conditional sentences. Conditional or "If" sentences consist of two clauses: the dependent clause expressing the condition and the main clause expressing the consequence (Conditional clauses, 2020). For comparison, type I conditional sentences refer to future events, e.g., "If I have the money, I will buy this car." Type II sentences refer to future or present events which are unlikely or impossible, e.g., "If I had the money, I would buy this car." While type III refer to past events which might have happened but did not, e.g., "If I had had the money, I would have bought that car." Thus type III conditional sentences are hypothetical and counterfactual.

Conditional sentences are a very interesting grammatical construction. They are used for constructing logical arguments, future planning, hypothesis-making. Therefore, it is logical to suppose that the acquisition of the conditional is important not only for linguistic skills but also for the understanding of and being able to communicate effectively about many parts of the curriculum, particularly Science and History. Examples of type III conditionals that children might encounter in their school work: for history: "If Germany had not invaded Poland, then the second world war would not have happened"; and for science: "If you had dropped the potassium in the water bath, you would have been burnt". A recent study by Svirko, Gabbott, Badger and Mellanby (2019) found that comprehension of hypothetical conditional sentences, specifically type II and type III, was predictive of children's understanding of certain scientific principles, independently of intelligence. The authors propose that understanding the conditional sentences actually helped children form the understanding of these principles of scientific investigation.

The authors have previously (unpublished, available from authors) carried out a large pilot study of the production of conditionals by 477 four and five-year-olds in a semi-structured interview situation using questions about posters of subjects well known to the children such as Sam the Fireman and Thomas the Tank Engine. They found that about 60% of the children produced one or more conditional within a four-minute interview, but the conditionals were of a simple type. A particularly important finding was that the ability to produce conditionals at age four-five years was predictive of reading, spelling and reading comprehension one year later. This suggested to the authors that a more rigorous investigation of the acquisition of conditionals from age six onwards, when children would be more likely to be familiar with complex conditionals, and reading would be worthwhile.

Despite conditional sentences being so interesting, it is not clear from the published research when the full scope of the conditional grammar is acquired by native English speakers. It appears that the first use of the "if" connective emerges in children's speech at around the age of two and a half (e.g., Bloom, Lahey, Hood, Lifer, & Fiess, 1980; Bowerman, 1986). However, at the beginning the children's sayings that include the "if" connective are short and often do not even constitute full sentences. Amidon (1976) investigated the comprehension of several sentence types including conditional sentences and found big improvement in children's understanding of these sentences between the ages of 5 and 7 years. However, from the information given in her paper it appears that Amidon's project only included type I conditional sentences.

Badger and Mellanby (2018) conducted an investigation specifically of the acquisition of type II and III conditional sentences. They tracked 517 children aged 5-7 years across a 9-month period. At the end of the study, among the oldest group of children (age 7), 71% could repeat type II sentences and 52% could repeat type III sentences. Only fewer than 20% of these children could understand either type II or type III conditionals. In Svirko et al's (2019) study children aged 8-9 years showed varied performance on tests of repetition and comprehension of type II and III conditional sentences, and there were no ceiling effects. Thus, these sentences are not fully acquired by that age either.

Interestingly, adults have been shown to differ in their comprehension of complex conditionals, sometimes interpreting a conditional as implying its converse (Evans, Handley, Neilens & Over, 2008). Thus it is possible that some children never fully acquire the complex conditionals. It appears from research on congenitally deaf children acquiring sign language at different ages (Newport, 1990) that there is a sensitive period for the implicit acquisition of grammar which might close in adolescence. Since sign language is a true language with highly complex grammatical structure it is likely that there is also a sensitive period for acquiring spoken language. Study of the very rare cases where spoken language has been withheld from children (e.g., the case of Genie, who suffered from extreme privation including almost complete social isolation until her discovery at age 13, Curtiss 1977) has shown a much greater sensitivity of grammar acquisition than vocabulary to such deprivation. This puts a new perspective on the timely acquisition of complex conditionals. If children for some reason do not acquire such grammar before the end of the sensitive period, they might always struggle with these academically important sentences (Mellanby & Theobald, 2014).

The current project focuses on type III conditionals. These sentences are both hypothetical and counterfactual. It has been shown that children as young as four can do simple counterfactual reasoning tasks (Harris, German, & Mills, 1996) and that these are simpler for children than the Theory of Mind tasks (German & Nichols, 2003; Perner, Sprung, & Steinkogler, 2004). On the other hand, counterfactual conditionals tend to appear in speech later than the other types of conditional sentences (Bowerman, 1986). There is some evidence indicating that type III conditionals are the least frequently used out of different conditional sentences in the English language (Hwang, 1979, cited in Celce-Murcia & Larsen-Freeman, 1999, p. 557). So it is likely that children have less exposure to this type of sentence than the other types. Also type III conditional sentences tend to be long, thus likely to be putting strain on verbal STM. Badger and Mellanby's findings suggest that children find these sentence types the most challenging.

Testing type III conditionals would be difficult to do with the most common methods of testing grammar: their hypothetical counterfactual nature makes it unworkable to represent them pictorially or to get children to act out the sentences or coerce them to produce them spontaneously. In the current project a test was designed based on Elicited Imitation (repetition) method. This method involves a child listening to sentences and repeating them precisely. Research has shown that such repetition is not a passive copy but involves the reconstruction of the sentence by the child and thus requires some extent of grammatical competence (Klem et al., 2015; Lombardi & Potter, 1992; Potter & Lombardi, 1990). The repetition method has been used in a variety of studies (e.g., Badger & Mellanby, 2019; Fraser, Bellugi & Brown, 1963; Håkansson & Hansson, 2000; Rodd & Braine, 1971; Svirko, Gabbott, Badger & Mellanby, 2019), and has been shown to have good test-retest reliability (Gallimore & Tharp, 1981) and convergent validity, i.e., it is related to grammatical competence as indicated by other measures (e.g., Bloom, Hood & Lightbown, 1974; Gallimore & Tharp, 1981; Klem et al, 2015). Also, Eadie, Fey, Douglas and Parsons (2002) found that children with SLI and Down Syndrome, who demonstrate considerable grammar difficulties show poorer performance on a repetition task than children with typically developing language. The repetition method aims to tap directly into the grammatical representations, it does not require the child to fully understand the sentence meaning. It is a more direct way of testing grammatical representations than syntactic priming, which is not a reliable method to use while the representations are still being formed. The conditional repetition test devised for this study is described in detail in the following section.

To summarize, in this study, the authors investigated the acquisition of type III conditionals from age six to age nine and measured the relationship between this and non-verbal intelligence, verbal STM (with non-verbal STM included for comparison) and WM. The authors also examined the relationship with reading performance. The main hypotheses were:

- Acquisition of Type III conditional sentences is related to verbal short-term memory, independently of non-verbal intelligence.
- Acquisition of Type III conditional sentences is related to working memory, independently of non-verbal intelligence.
- Acquisition of Type III conditional sentences predicts reading performance, independently of non-verbal intelligence.

2. Methodology

2.1. Participants

The initial cohort consisted of every child entering school Year 1 in four non-selective UK primary schools, excluding those with diagnosed learning disabilities (n=5), non-native English speakers (n=3) and those whose parents refused their participation (n=4), leaving the initial cohort size at 151 children (43.7% boys, mean age at first testing 5 years 10 months). Non-Caucasian children comprised 6% of the cohort. Two of the participating schools had mostly urban and two suburban catchment areas.

At each stage in the study some children were lost from the cohort due to their changing schools. 128 children (45.3% boys) were left at the last testing session to include Conditional Sentence Repetition test (Autumn term of Year 4, see Table 1). This is the sample size used in most analyses in this study.

2.2. Data collection and processing

This investigation is part of a larger project looking at the development of language, reasoning, working memory, mathematical skills, and reading. The project is a longitudinal study where information was gathered throughout the six primary school years starting from Year 1. There were two individual testing sessions in Autumn and Summer terms of Years 1-4 and one in Autumn terms of Year 5 and 6. Table 1 lists the testing sessions relevant to this study.

Table 1
Testing sessions, timing and contents

Testing Session	School Year	School Term	Testing Period	Tests Administered
1	1	Autumn	Oct.-Nov.	Forward Digit Span Backward Digit Span Block Recall
2	1	Summer	May-June	TROG-E[1] Non-Word Recall
3	2	Autumn	Oct.-Nov.	Forward Digit Span Backward Digit Span Conditional Sentence Repetition NNAT[2]
4	2	Summer	May-June	WORD[3]
5	3	Autumn	Oct.-Nov.	TROG-E Non-Word Recall
6	3	Summer	May-June	Forward Digit Span Backward Digit Span
7	4	Autumn	Oct.-Nov.	Conditional Sentence Repetition
8	4	Summer	May-June	WORD
9	6	Autumn	Oct.-Nov.	Hodder Reading Test

[1]*TROG-E = Test for Reception of Grammar, Electronic version*
[2]*NNAT = Naglieri Non-verbal Ability Test*
[3]*WORD = Wechsler Objective Reading Dimensions*

Each testing session lasted 20-35 minutes, depending on the child's ability. The order of tests within each session was kept constant. NNAT was administered in group sessions of 6-10 children. Hodder Group Reading Test was administered to each class with the help of the teacher and teaching assistants.
One of the authors spent a day at each school before the testing in order to introduce herself to the children. The testing at each school was conducted in a quiet area outside the classrooms. Children were given 1-2 minute breaks where necessary to minimize the effects of fatigue and loss of attention.

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2.3. Measures

2.3.1. Conditional Sentence Repetition Test

The Conditional Sentence Repetition test is based on the Elicited Imitation method (e.g., see Lust, Flynn & Foley, 1996) and consists of the child listening to the experimenter clearly enunciating the sentence and repeating exactly what the experimenter says. The test comprises four type III conditional sentences and four control sentences.

Conditional and control sentences were devised so that each conditional sentence had roughly the same number of words and syllables (+/- one) as its control sentence, and that each conditional and control sentence pair consisted of the same words as much as possible. (The number of words ranged from 11 to 15, the number of syllables within a sentence ranged from 16 to 18.) The reasoning is that if the child cannot repeat a conditional sentence but can repeat a grammatically simpler sentence of the same length, then they must have a problem specifically with the conditional sentence's grammatical structure (Lombardi & Potter, 1992; Potter & Lombardi, 1990). Presumably those who have not acquired this grammatical construction cannot successfully represent it in short term memory and thus would not be able to reproduce a conditional sentence. Those who have acquired this grammatical construction should be able to reproduce both experimental and control sentences.

The test sentences were pre-recorded using a female native English speaker and were played out using Superlab computer program. Each participant listened to the stimuli through headphones. Four conditional-control pairs were used, arranged into two blocks of four sentences. For each sentence, one of the blocks contained its conditional and the other its control version. The two blocks were presented within the same session but with some other tests in between them. Two commonly used names, Peter and Simon, were used as agents in the sentences. In one block the agent was Simon and in the other it was Peter.

The first block to be presented always started with a practice sentence. If the child did not repeat it accurately, s/he was asked to try again and the importance of repeating the sentence exactly was emphasized. Each block contained two conditional sentences and two controls. It was randomly chosen which two sentences would have the conditional version in the first block and which the control. The remaining versions of each sentence comprised the second block.

It was randomized between children in what order these two blocks were presented and also in which block the agent was Simon and in which Peter. (Appendix A shows the four variations of the conditional test.) The order of sentences within each block was randomized for each child.

The instructions given to the child were:

Block A: "Please, listen to some things about Simon/Peter and say back to me exactly what you hear. OK?"

Block B: "Now we are going to listen to some more things, this time about Peter/Simon. You need to listen carefully and say back to me exactly what you hear."

Children's responses were audio recorded. The recordings were then transcribed and scored.

The test was administered twice during the study: at the beginning of Year 2 and at the beginning of Year 4. A different version of the test was given to each child during the second administration.
Pilot testing revealed that the repetition task was difficult for children (due to unfamiliarity of the task and the need for them to speak out, which some children found surprisingly grueling) and thus the less than perfect performance (fewer than four out of four correct) on the test was not necessarily due to poorer grammar competence. Children who were less willing to speak out sometimes hesitated too long and forgot the sentence. In such cases children tended to perform better as the testing progressed as they became more familiar with the task and more comfortable with speaking out. Since the actual number of items repeated correctly was not always an indicator of the degree of grammatical competence, categorical classification of test performance was applied. The probability of repeating two target items correctly by chance was very low, thus it was considered that children who repeated two or more conditional sentences correctly must have acquired the type III conditional grammar at least to some degree. Thus two or more out of four target sentences correct was scored as a “Pass”.

2.3.2. Test for Reception of Grammar

Test for Reception of Grammar, electronic version (TROG, Bishop, 2005) is a standardized test assessing the understanding of grammatical constructs in the English language. It involves sentences being read aloud by a computer to the child who then has to choose from four pictures which one depicts that described by the sentence. The sentences are grouped into blocks of four, with each block, 20 in total, testing the understanding of a specific sentence type. The final score, the number of blocks, is converted into an age-standardized score. TROG is a strictly comprehension test and does not require children to produce any sentences while being tested. Also TROG does not include the conditional as one of the tested grammatical constructs.

2.3.3. Naglieri Nonverbal Ability Test

Naglieri Nonverbal Ability Test (NNAT, Naglieri, 1997) is an extension and revision of the Matrix Analogies Test (Naglieri, 1985). It is a standardized measure of non-verbal general intelligence designed to be culture fair: factual knowledge and vocabulary, mathematics and reading skills are not prerequisites for solving NNAT items. The items on this test require children to examine the relationships among parts of a design and select the correct response out of five choices provided, based on the information inherent in the item.

2.3.4. Automated Working Memory Assessment

Automated Working Memory Assessment (AWMA, Alloway, Gathercole & Pickering, 2004) is an electronic battery of short-term memory (STM) and working memory (WM) tests. Four subtests of AWMA were used in this study. They were non-word recall (recall of spoken lists of monosyllabic non-words, tests verbal STM), forward digit span (recall of spoken lists of digit names, tests verbal STM), backward digit span (involves the child attempting to repeat a spoken sequence of digits in reverse order on each trial, tests

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WM), and block recall (the child watches a video recording of an experimenter tapping a sequence of blocks arranged unsystematically in a three-dimensional array and has to reproduce the sequence in the same order, tests visuo-spatial STM). In each of these tests, the length of sequences of information that has to be recalled increases as the test progresses. The test program computes raw and age standardized scores for each test.

2.3.5. Wechsler Objective Reading Dimensions

The Wechsler Objective Reading Dimensions (WORD; Wechsler, 1993) is a standardized test of literacy skills. It consists of three subtests: Basic Reading (single words), Spelling (to dictation) and Reading Comprehension. Reading Comprehension involves the child reading passages of one or more sentences of text, and answering orally presented questions related to the text. Spelling subsection was not administered in Year 4 due to time constraints, therefore, only the reading subsections were analyzed. The test stimuli do not include conditional sentences.

2.3.6. Hodder Group Reading Test

Hodder Group Reading Test (Vincent & Crumpler, 2007) is a standardized test assessing children's reading comprehension. It takes 30 minutes to administer and can be administered to the whole class or year group. It includes questions which assess children's understanding of word meanings, culturally neutral sentence-completion questions, and questions that require children to understand continuous text and reflect upon its content and context. The test stimuli do not include conditional sentences.

2.4. Data analysis

Statistical analyses were carried out using SPSS version 22. (IBM Corp, Armonk, NY). Conditional sentence repetition test performance was not related to within-the-year age differences. For other tests, age-standardized scores were used in the analyses.

Conditional sentence repetition test performance was scored as a binary variable (Pass/Fail), therefore, logistic regressions were used to analyze which factors contribute to conditional sentence acquisition. When it was required to examine the relationship with conditional sentence repetition while controlling for one or more variables, hierarchical (fixed-order entry) logistic regressions were utilized and the change in model fit with adding the variable of interest (with controlled variables already in the model) was examined, as well as the significance of the Odds Ratio. Thus it was possible to judge whether the additional contribution of the variable of interest significantly improved the prediction on top of the variables already in the model. An outline of each model structure is provided in Appendix B. Because of the large numbers of scores available due to testing being conducted over five years, strict rules were followed when constructing the regression models, based on temporal priority and the most likely causal priority. Non-verbal intelligence was always entered first. STM has been shown to contribute to reading skills (e.g., Muter & Snowling, 1998; Garlock, Walley & Metsala, 2001), so it was a predictor in the model when looking at reading skills. It was assumed to similarly have causal priority before grammar acquisition.

In analyses where conditional sentence repetition was one of the predictors and the dependent variable was continuous, linear hierarchical (fixed-order entry) regressions were used. The normality of variable distributions was checked using Kolmogorov-Smirnov test and histogram representations of the data, making sure the data was suitable for this parametric analysis. The change in the amount of variance accounted for (R^2 change) in the outcome with the addition of predictors of interest was examined.

3. Findings

The average scores obtained on the standardized language/literacy/intelligence measures administered can be observed in Table 2.

Table 2
Descriptive statistics for standardized language and literacy test scores

Test Administered	N	Mean	SD*
TROG in Year 1	128	97.36	13.48
TROG in Year 3	128	94.17	14.87
NNAT in Year 2	128	97.63	16.81
WORD Reading in Year 2	128	100.06	16.99
WORD Comprehension in Year 2	128	95.16	16.94
WORD Reading in Year 4	121	100.83	14.23
WORD Comprehension in Year 4	121	97.02	13.69
Hodder Reading Test in Year 6	113	101.49	16.26

* Standard Deviation

The average scores on the standardized intelligence, language and literacy tests are all close to 100, the population mean. Where they deviate from 100, they are still less than one standard deviation away from it. This suggests that the current cohort is representative of the population, the children do not show an unexpectedly high or low performance in any of these areas.

3.1. Type III conditional sentence acquisition

During one session the child was required to repeat four target sentences (type III conditionals) and four control sentences (simple sentences of the same length). Control sentences were not scored but were used to establish that each child was capable of repeating simple sentences. Administration of these sentences was checking for articulation, memory and/or other problems severe enough to make the child unable to take part in the test. Of the children that remained in the study up to Year 4 and thus were part of the final cohort, no exclusions were made. Each target sentence was marked as correct or incorrect and the repetition of two or more out of four was scored as a “Pass”.

Note: The substitution of nouns in the sentence for semantically similar ones was allowed, as long as the grammatical structure of the sentence was correct. The observation that children did occasionally make such substitution errors supports the premise that children were reconstructing the sentences in order to repeat them rather than simply parroting them word for word.

At the beginning of Year 2, 26.6% of children passed Conditional Sentence Repetition Test and at the start of Year 4, 57% did so (see Figure 1).

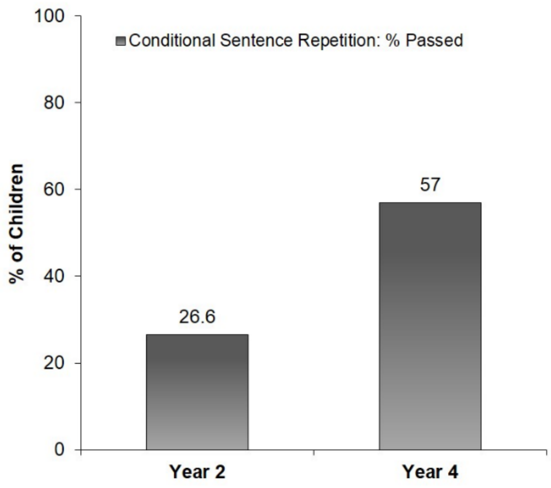

Figure 1. Performance on Conditional Sentence Repetition Test in Year 2 and Year 4

All the children who demonstrated type III conditional acquisition in Year 2 also passed the conditionals test in Year 4.

Passing Conditional Sentence Repetition Test was not related to within-the-year age differences (t-tests showed that those who passed and those who failed were not significantly different in age either in Year 2 (p = .95) or Year 4 (p = .73)

3.2. Conditional sentence acquisition and general grammar comprehension

Analyses were performed where one set of grammar scores was used to predict another a year later, controlling for non-verbal intelligence (see Models 1 and 2, Appendix B). Grammar comprehension in Year 1, as indicated by TROG, significantly predicted conditional sentence repetition performance (pass/fail) in Year 2 (Wald χ^2 = 13.06, df = 1, p < .001, Odds Ratio (OR) [95% CI]=1.07 [1.03;1.11]), independently of non-verbal intelligence (NNAT). Conditional sentence acquisition in Year 2 significantly predicted grammar comprehension scores in Year 3 (ΔR^2 = .141, $F(1,125)$ = 28.08, p < .001), controlling for non-verbal intelligence. Thus a bi-directional relationship with an established standardized measure of grammar comprehension was demonstrated.

3.3. Conditional sentence acquisition and short-term and working memory

In Year 1 children were administered four different measures of short-term memory (STM) and working memory (WM). Relating them to conditional sentence repetition in Year 2 (Model 3, Appendix B), Block Recall, a measure of visuo-spatial STM, was not predictive of passing the repetition test, independently of non-verbal intelligence (see Table 3). Neither was Non-Word Recall, a measure of verbal STM which uses unfamiliar verbal stimuli. On the other hand, Forward Digit Span, a measure of verbal STM with highly familiar verbal stimuli, did significantly predict conditional sentence performance, independently of non-verbal intelligence.

Table 3
Results of logistic regressions predicting conditional sentence repetition performance (pass/fail) in Year 2 from earlier and concurrent STM and WM scores controlling for NNAT

Independent variable entered after NNAT	Model change χ^2	*p*	OR	95% CI	
Forward Digit Span in Year 1	7.93	.005	1.04	1.01	1.06
Backward Digit Span in Year 1	4.25	.039	1.03	1.00	1.05
Non-word Recall in Year 1	.81	.368	1.01	.988	1.03
Block Recall in Year 1	.87	.352	1.30	.747	2.26
Forward Digit Span in Year 2	4.83	.028	1.03	1.00	1.07
Backward Digit Span in Year 2	.70	.403	1.01	.982	1.05

For each independent variable df = 1

Backward Digit Span, a measure of WM with familiar verbal stimuli, was also a significant predictor of passing conditional sentence repetition a year later. However, STM is a prerequisite for WM test performance and it was found that Backward Digit Span scores in Year 1 did not add a significant contribution to prediction on top of Forward Digit Span in Year 1 (Model change χ^2 = .44, p = .508). Also concurrent Forward Digit Span scores were significantly related to conditional sentence performance, but concurrent Backward Digit Span scores were not.

Next the Forward Digit Span scores gathered over the first three years of primary school were related to conditional sentence repetition performance in Year 4 (Model 4, Appendix B). Forward Digit Span in Year 1 and Year 2 significantly predicted passing conditional sentence repetition in Year 4, controlling for non-verbal intelligence (Table 4). The relationship between Forward Digit Span at the end of Year 3 and conditional sentence repetition performance in Year 4, i.e., roughly three months later, was marginally non-significant (p=0.052).

Table 4
Results of logistic regressions predicting conditional sentence repetition performance (pass/fail) in Year 4 from Forward Digit Span scores, controlling for NNAT

Independent variable entered after NNAT	Model change χ^2	p	OR	95% CI	
Forward Digit Span in Year 1	7.30	.007	1.03	1.01	1.06
Forward Digit Span in Year 2	10.17	.001	1.05	1.02	1.08
Forward Digit Span in Year 3	3.79	.052	1.02	.998	1.05

For each independent variable df = 1

Further analysis (Model 5, Appendix B) showed that, importantly, Forward Digit Span in Year 2 significantly predicted conditional sentence repetition in Year 4, even controlling for the almost concurrent (end of Year 3) Forward Digit Span scores, as well as non-verbal intelligence : after adding Forward Digit Span in Year 2, Model change χ^2 = 5.68, p = .017, OR [95% CI] = 1.05 [1.01;1.09]. This analysis further confirms the importance of early verbal STM scores as opposed to later in relation to conditional sentence acquisition.
For completeness, it was noted that early Backward Digit Span scores and Non-Word Recall scores were significant predictors of Year 4 conditional sentence repetition, controlling for non-verbal intelligence, but none of these measures remained significant predictors on top of Forward Digit Span. Thus it is the variance that these test scores share with Forward Digit Span that was predictive conditional sentence performance.

3.4. *Conditional sentence acquisition and literacy*

A series of hierarchical (fixed-order entry) regressions were performed where passing conditional sentence repetition test early (Year 2) was related to reading scores obtained at different times, controlling for non-verbal intelligence and concurrent verbal STM (Model 6, Appendix B).

Table 5
Results of regressions predicting reading performance from conditional sentence repetition (Pass/Fail) in Year 2, controlling for NNAT and Forward Digit Span in Year 2

Independent variable entered after NNAT and Forward Digit Span in Year 2	Dependent Variable	R^2 Change	F change	df	p	Final Model β	p for β
Conditional Sentence Repetition in Year 2	WORD reading Year 2	.044	7.54	1,124	.007	.22	.007
	WORD reading comprehension	.043	8.32	1,124	.005	.22	.005

	Year 2						
	WORD reading Year 4	.078	11.83	1,117	.001	.29	.001
	WORD reading comprehension Year 4	.058	10.06	1,117	.002	.25	.002
	Hodder reading comprehension Year 6	.094	12.93	1,109	<.001	.32	<.001

As can be seen from Table 5, conditional sentence acquisition measured at the start of Year 2 was a significant predictor of performance on single word reading and reading comprehension tested at the end of Year 2 and Year 4, and of reading comprehension tested in Year 6, accounting for a significant amount of variance on top of non-verbal intelligence and verbal STM.
Another series of analyses examined the relationship between the later conditional sentence repetition performance and reading scores (Model 7, Appendix B).

Table 6
Results of regressions predicting reading performance from conditional sentence repetition (Pass/Fail) in Year 4, controlling for NNAT and Forward Digit Span in Year 3

Independent variable entered after NNAT and Forward Digit Span in Year 3	Dependent Variable	R^2 Change	*F* Change	df	*p*	Final Model β	*p* for β
Conditional Sentence Repetition in Year 4	WORD reading Year 4	.020	2.81	1,117	.097	.15	.097
	WORD reading comprehension Year 4	.020	3.53	1,117	.063	.15	.063
	Hodder reading comprehension Year 6	.054	6.99	1,109	.009	.24	.009

The results indicate that at this age (8-9 years), conditional sentence performance does not predict reading performance towards the end of the academic year, independently of non-verbal ability and verbal STM. However, it does predict reading comprehension performance two years later (Table 6).

3.5. *Conditional sentence acquisition, early grammar comprehension and literacy*

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Can the performance on conditional sentence repetition test tell us anything beyond an established general measure of grammar acquisition? In order to answer this question conditional sentence repetition performance was related to reading scores, controlling for general grammar comprehension performance, as indicated by TROG, as well as non-verbal intelligence and verbal STM (Model 8 and 9, Appendix B).

Table 7
Results of regressions predicting reading performance from conditional sentence repetition (Pass/Fail) in Year 2, controlling for NNAT, Forward Digit Span and TROG

Regression block	Independent Variables	Dependent variable	R^2 Change	*F* change	df	*p*
1	NNAT Forward Digit Span in Year 1	WORD reading Year 2	.24	20.00	2,125	<.001
2	TROG in Year 1		.01	2.12	1,124	.148
3	Conditional Sentence Repetition in Year 2		.03	4.77	1,123	.031
1	NNAT Forward Digit Span in Year 1	WORD reading comprehension Year 2	.33	30.19	2,125	<.001
2	TROG in Year 1		.02	3.91	1,124	.05
3	Conditional Sentence Repetition in Year 2		.02	4.63	1,123	.033
1	NNAT Forward Digit Span in Year 1	WORD reading Year 4	.18	13.19	2,118	<.001
2	TROG in Year 1		.01	1.16	1,117	.284
3	Conditional Sentence Repetition in Year 2		.06	8.43	1,116	.004
1	NNAT Forward Digit Span in Year 1	WORD reading comprehension Year 4	.31	26.02	2,118	<.001
2	TROG in Year 1		.05	8.07	1,117	.005
3	Conditional Sentence Repetition in Year 2		.02	4.08	1,116	.046
1	NNAT Forward Digit Span in Year 1	Hodder reading comprehension Year 6	.18	11.93	2,110	<.001
2	TROG in Year 1		.02	3.11	1,109	.081
3	Conditional Sentence		.05	7.23	1,108	.008

	Repetition in Year 2					
1	NNAT Forward Digit Span in Year 3	WORD reading Year 4	.15	10.75	2,118	<.001
2	TROG in Year 3		.09	13.47	1,117	<.001
3	Conditional Sentence Repetition in Year 2		.04	7.05	1,116	.009
1	NNAT Forward Digit Span in Year 3	WORD reading comprehension Year 4	.29	24.11	2,118	<.001
2	TROG in Year 3		.10	19.09	1,117	<.001
3	Conditional Sentence Repetition in Year 2		.03	5.17	1,116	.025
1	NNAT Forward Digit Span in Year 3	Hodder reading comprehension Year 6	.10	6.32	2,110	.003
2	TROG in Year 3		.11	15.84	1,109	<.001
3	Conditional Sentence Repetition in Year 2		.05	7.68	1,108	.007

Passing conditional sentence repetition test in Year 2 remained a significant positive predictor of later performance on single word reading and reading comprehension in Year 2 and Year 4 and reading comprehension in Year 6 (see Table 7), controlling for non-verbal intelligence, verbal STM and early general grammar development, or even later grammar development measured in Year 3 (age 8-9).

An additional analysis revealed that conditional sentence repetition performance in Year 4 made a small but significant contribution to reading comprehension performance in Year 6 ($\Delta R^2 = .03$, $F(1,108) = 4.42$, $p = .038$), after controlling for general grammar development, in addition to non-verbal intelligence and verbal STM (Model 10, Appendix B).

4. Conclusions and Discussion

4.1. Conditional sentence acquisition

It was found that in the early primary school years only some children show evidence of acquisition of complex conditional sentences. Specifically, only about one quarter of children showed evidence of internalizing the type III conditional sentence grammar at age 6 (at the start of UK Year 2 of schooling). A further 30% of children acquired the type III conditionals over the next two years, with the acquisition rate being 57% by age 8 years (start of primary school Year 4). These findings are in line with those of Badger and Mellanby (2018) who also used the repetition method and report 52% acquisition rate for type III conditionals by age 7-8 years. Since conditionals are not taught at this stage of British education, this acquisition of type III sentences has presumably taken place implicitly in response to exposure.

Conditional sentence performance was both predicted by and predictive of general grammar development measured by the more commonly used picture-pointing method in language assessment, namely the standardized Test for Reception Of Grammar (TROG, Bishop, 2005), which supports the validity of the repetition test. A closer relationship would not be expected because TROG is a test of grammar comprehension, thus performance depends on both syntactic and semantic processing, while the repetition test mostly taps into implicit grammatical representations. Also, TROG tests a wide range of grammatical constructions, none of which is the conditional, and gives a score on a continuous scale, while the repetition test tests one grammatical construct and provides a binary outcome, thus it cannot be expected that the outcomes of these two tests would be very closely aligned.

An indication of the validity of the repetition method were the substitution errors made by children, supporting that sentence reconstruction rather than word-for-word parroting of stimuli was taking place.

4.2. Short-term and working memory

Of the measures of short-term (STM) and working memory (WM), after controlling for non-verbal intelligence, early (Year 2) conditional sentence performance was predicted by Forward Digit Span, which is a measure of verbal STM; and the relationship seemed stronger with the earlier, rather than concurrent verbal STM scores. Another common measure of verbal STM, Non-Word Recall, did not show the same relationship with conditional sentence repetition. Performance on Non-Word Recall, in addition to measuring verbal STM, is influenced by phonological awareness (assuming better phonological awareness equals more distinct phonological representation of unfamiliar verbal stimuli), whereas Forward Digit Span involves only very familiar (for that age group) verbal stimuli, and thus arguably reflects only the verbal STM capacity. Looking at conditional sentence acquisition at a later stage, Forward Digit Span scores, in particular the early (Year 1 and 2) scores continued to be significant predictors of passing the test for this grammatical construct. Even though other verbal STM and WM measures this time were also significant predictors, they did not predict conditional sentence acquisition beyond non-verbal ability and Forward Digit Span. These findings together suggest that it is not STM for any stimuli including visuo-spatial (Block Recall), not phonological representation (Non-Word Recall) and not the ability to manipulate verbal stimuli while holding them online (Backward Digit Span) that is related to the acquisition of complex conditional sentences. It is specifically the verbal STM capacity. Thus hypothesis 1 was confirmed and hypothesis 2 was not.

One important question is whether verbal STM plays a role in the acquisition or whether greater verbal STM capacity simply means more efficient processing of complex conditional sentences. Further analysis suggests that the former is more likely. Early verbal STM scores were a significant predictor of Year 4 conditional sentence performance even controlling for the later verbal STM scores. This could be because verbal STM plays a role in the process of acquisition but becomes less important once the acquisition is complete. The mechanism would be that once grammar has been internalized the processing takes up less capacity, so the size of the person's STM span becomes less important.

It seems to be generally accepted that sensory input is instrumental to functional specialization of at least some brain areas. This is attested to, for example, by the recruitment of some right hemisphere areas into language processing in native users of American Sign Language (ASL) presumably in response to the visuo-spatial nature of the language input (Newman, Bavelier, Corina, Jezzard, & Neville, 2002), or the recruitment of traditionally visual areas into the processing of Braille in blind individuals (Cohen et al., 1997; Sadato et al., 1996). What seems to have been overlooked is that STM capacity has direct bearing on what sensory input is available. Once sentence grammar has been acquired less STM capacity is taken up by sentences than unrelated strings of words of the same length, as has been shown by experiments demonstrating that adults can recall twice as many words in the correct order when they form a sentence (Brener, 1940). However, when the child, whose complex grammar acquisition is not complete, encounters complex sentences with unfamiliar grammatical structure, it is possible that those with greater verbal STM span would be able to hold more of the sentence online and might internalize the sentence structure sooner than those with limited STM capacity. It is possible that this is the way verbal STM system influences the amount of input available for grammar acquisition and thus plays a role in the grammar acquisition process. Such a mechanism would account for the results of the current study which suggest that verbal STM contributes to the acquisition of sentence grammar of type III conditionals. To test the suggested mechanism in detail it would be interesting to conduct an fMRI study and compare the activation patterns between children with low and high verbal STM capacity when presented with sentences with unfamiliar grammatical structure.

Considering cognitive development in general, in the introduction the neuroconstructivist hypothesis has been mentioned which postulates functional specialization forming through the process of development. As there is less specialization during development one would expect there to be more interaction between cognitive processes than the strictly modular view would predict – and the current study found that to be the case. The contribution of verbal STM to the acquisition of type III conditional sentences strongly suggests that there is no informational encapsulation/cognitive impenetrability during the process of grammar development, at least in the stages following infancy. The strictly modular view of grammar is not supported by the current study.

4.3. Reading skills

The hypothesis that the acquisition of complex conditional sentences would be predictive of later literacy (hypothesis 3) was generally confirmed. Early type III conditional sentence performance predicted reading performance, measured by established standardized tests, half a year, two and a half years and even four years later, controlling for non-verbal reasoning ability and verbal STM. Conditional sentence acquisition made a significant independent contribution to reading scores even on top of the standardized measure of general grammar development (TROG).

The results for conditional sentence performance at a later stage are less clear cut. Acquisition of type III conditionals in Year 4 was not predictive of reading scores obtained half a year later, when controlling for non-verbal reasoning ability and verbal STM. However, it was predictive, not very strongly, but significantly, of reading comprehension two years later, even when controlling for generalized grammar development scores, as well as the domain-general factors.

It seems that early learning of complex conditional sentences is particularly useful at predicting reading performance, both single word reading and reading comprehension. However, even the acquisition at a later stage might provide some indication of reading achievement later on. Non-verbal intelligence and verbal STM do not account for this relationship. One possible mechanism for the observed relationship is that children with good grammar will be able to understand the sentences they are reading and thus at least in some cases would be able to work out what the word that they can't read is from the context. If they see the same word again, they might remember and be able to read it, thus improving their reading skills. This accounts for grammar acquisition being more strongly related to later reading performance. There needs to be time (and reading practice) for improved grammar to have this positive effect on reading. A question then emerges why type III conditional sentence acquisition in particular is predictive of later reading achievement, even beyond the general grammar comprehension level. The authors suggest that complex conditional sentences, specifically type III, are a particularly good marker of grammar acquisition problems. It has been shown in the past that grammar development is one of the important prerequisites for good reading skills, in particular reading comprehension (e.g., Rego & Bryant, 1993; Nation & Snowling, 2000; Hulme & Snowling, 2014). Delayed type III conditional sentence acquisition might be indicative of persistent problems with grammar, which will have an impact on other aspects of learning and school performance.

On another note, it is the early acquisition of complex conditionals that seems to be particularly predictive of later reading performance, suggesting that good grammar development early on will be advantageous for children's reading skills. Considering again the neurological aspects of development, if acquisition of complex grammar is delayed too late, the networks of the adult brain might not be flexible enough to fully accommodate the previously unassimilated grammatical complexities (linking to research on sensitive period for native language acquisition, e.g., Newport, 1990). Thus delays in acquisition of complex sentences such as type III conditionals might not only reflect poorly on reading skills, but might have a negative impact on all areas of performance where verbal skills are important. As mentioned in the introduction, complex conditionals are somewhat of a special case, even though they might not be used in everyday speech (e.g., Badger & Mellanby, 2018; Svirko, Gabbott, Badger & Mellanby, 2019). The areas where this aspect of language is particularly important are science (formulating hypotheses, describing different possible consequences for experimental manipulation) and history (considering hypothetical sequences of events if the trigger event, such as the assassination of Archduke Franz Ferdinand, had not occurred). As mentioned in the introduction, this postulation is supported a recent study (Svirko, Gabbott, Badger & Mellanby, 2019), which found children's comprehension of complex conditionals to be predictive of their understanding of scientific principles. Thus the incomplete acquisition of such sentences would in and of itself be a concern for educators.

4.4. Limitations

The current study focused on one aspect of type III conditional sentence acquisition. The repetition test used does not require sentence comprehension. It would be interesting to explore how comprehension of these sentences relates to reading performance. Also for the reasons described in the method binary scoring of the repetition test was used and in the current study the test was administered at two time points. It would be interesting to obtain a continuous measure of type III conditional grammar acquisition, for example, by including a few more conditional sentences into each test block and providing children with a longer introduction to the test. Also, in an educationally important study, the expanded test should be administered to children at the end of primary school (age 11) or beginning of secondary school (age 11-12) to determine whether there are children who have not acquired the type III conditionals by that stage. It should then be explored whether these children are behind on other aspects of complex grammar acquisition. The cause or causes of such delays in developmentally typical population should be identified.

4.5. Educational implications

Verbal STM but not non-verbal STM or verbal WM predicts later acquisition of type III conditional sentences and the results suggest that it actually contributed to the acquisition process, as opposed to being only required for sentence processing. Early acquisition of complex conditionals is predictive of future reading skills even beyond general grammar comprehension performance. Therefore, delayed acquisition of complex sentences such as type III conditionals could act as a marker for grammar problems. The Conditional Sentence Repetition test that has been devised for the current study takes only five minutes to administer and could be used by educators to identify children who might be in need of complex grammar intervention.

Putting to one side the consideration of a formal intervention, there are simple recommendations brought on by the current results that teachers could follow. For example, teachers could take special care to make frequent use of complex conditional sentences in the early years, as well as throughout primary school. As an initiative to improve grammar at the whole-class level, complex grammatical sentences could be delivered to children in stories (short stories, novels, fairytales, plays, etc.). In mid-primary school years, explicit teaching of complex conditionals could be introduced to assess children's progress with these grammatical constructions and ensure that all children are at least aware of such sentences and would be paying extra attention to them. The direction of attention is likely to lead to allocation of extra resources to processing and thus might lead to learning in children who have not managed to assimilate these sentences implicitly even with increased exposure through stories, etc. On a final note, it needs to be considered how improved grammar development might influence aspects of cognition other than reading skills. Type III conditional sentences are hypothetical and counterfactual, thus they provide a direct way of phrasing cognitively complex concepts. They are not short, but using such sentences is considerably briefer than having to describe or even consider these concepts without them. Therefore their use is likely to free up processing capacity which in turn might help with reasoning and problem solving. Here the discussion turns to the long-standing issue of the relationship between language and reasoning ability. It still has not been unequivocally answered whether more perfected verbal skills, such as ability to use complex sentences, help with processing of complex concepts or solving cognitively challenging problems. The authors believe that it is possible that complex language could give children a "leg-up" when they a are on the verge of tackling a cognitive hurdle that was previously beyond them. Other examples in cognition of such a "leg-up" include young children's need for concrete examples when solving certain types of problems, famously described by Piaget (Piaget & Inhelder, 1969). The need for concrete examples becomes redundant with development. Another example would be how the use of analogies in learning physics influences students' reasoning (e.g., Dunbar, 1995; Holyoak & Koh, 1987). This research shows that the students rely on the analogy to help their understanding, but they do need to have the necessary cognitive capacity to understand, otherwise the analogy would not help. Going back to the specific example of counterfactual conditional sentences, as mentioned in the introduction, even very young children seem to be capable of counterfactual reasoning. For example, a study by Harris, German and Mills (1996) with the experimenter using toys to act out scenarios and then asking questions of the type 'what would have happened if…' provides evidence that at least some five- and even three-year-olds are capable of a simple form of it. However, the large proportion of incorrect responses indicates that this is not an easily achieved way of thinking for that age. Neuroscientific research suggests that semantics and grammar processing are at least to some extent separate (Friederici, 2011; Ullman, 2001). It would be interesting to investigate whether children can acquire the basic grammatical structure of counterfactual conditionals (enough to be able to reproduce them) before they could comprehend such sentences and whether such acquisition might speed up the development of reasoning necessary for comprehension.

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Appendix A
Conditional Sentence Repetition Test stimuli and presentation

Children were randomly assigned to one of the four versions of the Conditional Sentence Repetition Test (Table A1). The order of items within each block, with the exception of the practice item, was randomised for each child using Superlab computer program.

Table A1.

Four versions of the Conditional Sentence Repetition Test.

Version 1	**Version 3**
Block A	**Block A**
Practice: Simon goes to school every day and he has lots of friends.	Practice: Simon goes to school every day and he has lots of friends.
Simon picked some lovely flowers and he gave them to his mum and dad.	If Simon had picked some flowers, he would have given them to his mum.
If Simon had broken his toy, he would have tried to fix it.	Simon broke his favourite toy, and he tried hard to fix it.
If Simon had bought some ice cream, he would have shared it with his friends.	Simon bought a lot of ice cream and he shared it with his many friends.
Simon did not work very hard, so he did not pass the exam.	If Simon had worked harder, he would have passed the exam.
Block B	**Block B**
Peter bought a lot of ice cream and he shared it with his many friends.	If Peter had bought some ice cream, he would have shared it with his friends.
Peter broke his favourite toy, and he tried hard to fix it.	If Peter had broken his toy, he would have tried to fix it.
If Peter had worked harder, he would have passed the exam.	Peter did not work very hard, so he did not pass the exam.
If Peter had picked some flowers, he would have given them to his mum.	Peter picked some lovely flowers and he gave them to his mum and dad.
Version 2	**Version 4**
Block A	**Block A**
Practice: Peter goes to school every day and he has lots of friends.	Practice: Peter goes to school every day and he has lots of friends.
Peter bought a lot of ice cream and he shared it with his many friends.	If Peter had bought some ice cream, he would have shared it with his friends.
Peter broke his favourite toy, and he tried hard to fix it.	If Peter had broken his toy, he would have tried to fix it.
If Peter had worked harder, he would have passed the exam.	Peter did not work very hard, so he did not pass the exam.

If Peter had picked some flowers, he would have given them to his mum.	Peter picked some lovely flowers and he gave them to his mum and dad.
Block B	**Block B**
Simon picked some lovely flowers and he gave them to his mum and dad.	If Simon had picked some flowers, he would have given them to his mum.
If Simon had broken his toy, he would have tried to fix it.	Simon broke his favourite toy, and he tried hard to fix it.
If Simon had bought some ice cream, he would have shared it with his friends.	Simon bought a lot of ice cream and he shared it with his many friends.
Simon did not work very hard, so he did not pass the exam.	If Simon had worked harder, he would have passed the exam.

Appendix B
Summary of hierarchical (fixed-order entry) regression models used.

Strict rules were followed when constructing the regression models, based on temporal priority and the most likely causal priority. Non-verbal intelligence was always entered first. STM has been shown to contribute to reading skills (e.g., Muter & Snowling, 1998; Garlock, Walley & Metsala, 2001), so it was a predictor in the model when looking at reading skills. It was assumed to similarly have causal priority before grammar acquisition.

Findings subsection*: 3.2. Conditional sentence acquisition and general grammar comprehension*

Model 1
Step 1
    Non-verbal intelligence (NNAT)
Step 2
    General Grammar Comprehension (TROG) in Year 1
Outcome: Conditional Sentence Repetition (Pass/Fail) in Year 2

Model 2
Step 1
    Non-verbal intelligence (NNAT)
Step 2
    Conditional Sentence Repetition in Year 2
Outcome: General Grammar Comprehension (TROG) in Year 3

Findings subsection: *3.3. Conditional sentence acquisition and short-term and working memory*

Model 3

Step 1
Non-verbal intelligence (NNAT)

Step 2
Short-Term Memory (STM) or Working Memory (WM) measure Year 1, Year 2
Outcome: Conditional Sentence Repetition in Year 2

Model 4
Step 1
Non-verbal intelligence (NNAT)
Step 2
Forward Digit Span in Year 1, Year 2, Year 3
Outcome: Conditional Sentence Repetition in Year 4

Model 5
Step 1
Non-verbal intelligence (NNAT)
Forward Digit Span in Year 3 (end)
Step 2
Forward Digit Span in Year 2
Outcome: Conditional Sentence Repetition in Year 4

Findings subsection: *3.4. Conditional sentence acquisition and literacy*

Model 6
Step 1
Non-verbal intelligence (NNAT)
Forward Digit Span in Year 2
Step 2
Conditional Sentence Repetition in Year 2
Outcome: Reading Skills Test scores Year 2, Year 4, Year 6

Model 7
Step 1
Non-verbal intelligence (NNAT)
Forward Digit Span in Year 3 (end)
Step 2
Conditional Sentence Repetition in Year 4
Outcome: Reading Skills Test scores Year 4, Year 6

Findings subsection: *3.5. Conditional sentence acquisition, early grammar comprehension and literacy*

Model 8
Step 1
Non-verbal intelligence (NNAT)
Forward Digit Span in Year 1

Step 2
General Grammar Comprehension (TROG) in Year 1

Step 3
Conditional Sentence Repetition in Year 2
Outcome: Reading Skills Test scores Year 2, Year 4, Year 6

Model 9
Step 1
Non-verbal intelligence (NNAT)
Forward Digit Span in Year 3
Step 2
General Grammar Comprehension (TROG) in Year 3
Step 3
Conditional Sentence Repetition in Year 2
Outcome: Reading Skills Test scores Year 4, Year 6

Model 10
Step 1
Non-verbal intelligence (NNAT)
Forward Digit Span in Year 3
Step 2
General Grammar Comprehension (TROG) in Year 3
Step 3
Conditional Sentence Repetition in Year 4
Outcome: Hodder reading comprehension Year 6