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‘MetaTaal’: Enhancing complex syntax in children with SLI: A metalinguistic and multimodal approach

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Specific language impairment (SLI) is a neurodevelopmental language disorder that affects approximately 7% of kindergarten children (Tomblin et al., 1997) and can persist into adolescence and adulthood (Aram, Ekelman, & Nation, 1984; Beitchman, Wilson, Brownlie, Walters, & Lancee, 1996; Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1998). Children with SLI can experience difficulties in many areas of language, but problems with verb morphology and complex syntax are generally considered to be core symptoms of the disorder (Leonard, 1998). Persisting language impairment has severe effects both on academic achievements (Simkin & Conti-Ramsden, 2006) and psychosocial development (Clegg, Hollis, Mawhood, & Rutter, 2005).

There is a general consensus that speech and language problems should be identified and treated as early as possible to prevent future difficulties. To date, intervention for young (instead of older) children has received most attention from researchers. For instance, all 25 studies that were used in the meta-analysis by Law, Garrett, and Nye (2004) on the efficacy of treatment for children with developmental speech and language delay or disorders, concerned children age between 2;01 and 6;01 years; only two out of the 36 papers reviewed reported results on children older than eight years. Early language orientated interventions can also prevent the development of other learning difficulties (Gillon, 2000) and social-emotional problems (Robertson & Ellis Weismer, 1999). However, it has been found that language difficulties can persist in children with SLI (Law, Boyle, Harris, Harkness, & Nye, 2000; Johnson et al., 1999). The effect of speech and language therapy appears to depend on the type of problems: clear effects are found for children with phonological or vocabulary difficulties, but the effects of interventions for children with receptive difficulties and interventions aiming at expressive syntax are less robust (Law et al., 2003).

Furthermore, results of early intervention studies have to be interpreted with caution, as language delays appear to resolve spontaneously in a considerable proportion of two-year-old children (Bishop, 2008; Wake et al., 2011). To date, research on the efficacy of treatments for older children (i.e., between 9 and 12 years) with persistent language difficulties has remained scarce. Moreover, the existing evidence on effective interventions in older children has not been disseminated widely (Bishop, 2009). The fact that many services (in the UK at least) provide very little and often no therapy to children over 11

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years of age (Dockrell, Lindsay, Letchford, & Mackie, 2006; Lindsay, Dockrell, Mackie, & Letchford, 2005; Lindsay et al., 2002) may be related to a lack of efficacy studies (Ebbels, 2007).

Although there are no official clinical guidelines in the Netherlands for the treatment of children with language disorders (Gerrits, 2011), standard clinical practice in Dutch special education settings is that treatment for children with SLI older than 9 years focuses on minimizing the impact of disability, rather than remediation of grammar or vocabulary. Thus, it is mostly children aged 4 to 8 years who are given therapy (Fortgens, 2009; Willemsen, 2009).

The policy to limit language interventions in older children with SLI can be questioned. Impoverished grammatical abilities impede a variety of crucial domains in the development of children and young adolescents with SLI. For example, grammar plays an important role in narrative skills (Norbury & Bishop, 2003) and these skills are central to daily social interactions and academic performance (Conti-Ramsden, Durkin, Simkin, & Knox, 2009; Tannock, Purvis, & Schachar, 1993). Poor language skills are reported to be related to a lower social and behavioural status. Children with SLI also have a higher risk of becoming regular victims of bullying (Conti-Ramsden & Botting, 2004). Furthermore, the level of independence of adolescents with SLI is negatively impacted by poor language and literacy skills (Conti-Ramsden & Durkin, 2008).

In summary, intervention programmes to enhance grammar for children with SLI between 9 and 12 years are sparse, whereas the impact of poor grammatical skills may be large in later adolescence. The current situation can only change if more evidence for the effectiveness of intervention for older children is provided. The present study aims to contribute to the body of evidence by investigating a multimodal and metalinguistic intervention approach in Dutch children with SLI from nine years upwards.

Metalinguistic intervention: rationale and effectiveness

Therapy approaches for young (pre-school) children mainly train morphosyntactic skills implicitly, using techniques like recasting, elicited imitation and modelling (Fey & Proctor-Williams, 2000). The idea behind these interventions is that young children with SLI are able to learn the selected grammatical targets when they are presented with an increased frequency and salience. Nonetheless, difficulties with morphosyntax and complex syntax often persist in older school-age children with SLI (Bishop, Bright, James, Bishop, & Van der Lely, 2000; Rosen, Adlard, & van der Lely, 2009; Van der Lely, 1997; Van der Lely & Stollwerck, 1997; Van Weerdenburg, Verhoeven, & van Balkom, 2006). This suggests that they have difficulties with learning language implicitly and, therefore, a different approach might be required (Ebbels, 2007). As children grow older, they develop the ability to reflect on the nature and properties of language enabling them to make explicit judgements about linguistic form (Menyuk & Chesnick, 1997; Van Kleeck, 1982). Metalinguistic interventions appeal to this ability by explicit instruction on language structures, often supported with specific visual cues (Ebbels, 2014). In the past two decades, several studies have provided evidence for the effectiveness of metalinguistic interventions that focussed on the

remediation of morphosyntax and complex syntax for older children and adolescents with SLI (Ebbels, 2007; Ebbels & van der Lely, 2001; Ebbels, van der Lely, & Dockrell, 2007; Hirschman, 2000; Levy & Friedman, 2009).

The rationale for metalinguistic intervention is based on the hypothesis that children with SLI have difficulties learning grammar implicitly and benefit from explicit teaching of grammatical rules (Ebbels, 2014; Ebbels, Mari, Murphy, & Turner, 2014). This hypothesis is in line with results suggesting that (implicit) procedural memory is impaired in children with SLI (Lum, Conti-Ramsden, Page, & Ullman, 2012; Ullman & Pierpont, 2005), whereas declarative memory (which supports explicit learning) appears to remain largely intact and can therefore play a compensatory role in learning grammatical rules (Ullman & Pierpont, 2005). Results showing that grammatical abilities were correlated with declarative memory skills in children with SLI, but with procedural memory in typically developing children (Lum, et al., 2012) are in line with this hypothesis. These findings indicate that children with SLI can engage their largely intact declarative memory system in order to learn grammatical rules explicitly instead of having to rely on their impaired procedural memory system (Ebbels, et al., 2014).

A typical feature of existing metalinguistic intervention practices is the use of visual support, such as writing, or the encoding of linguistic structure by shapes or colours. Spoken language is transitory and a visual representation offers children with SLI compensation for their limited capacity to process and store verbal information (Bishop, 1992, 1994; Ellis Weismer & Evans, 2002; Montgomery, 2000, 2003; Quail, Williams, & Leitão, 2009). Provision of visual cues can also help a child to develop a concrete explicit representation of grammatical structures, which may support comprehension and production (Ebbels & Van der Lely, 2001; Hirschman, 2000). Furthermore, a visual coding system can be used to correct the errors children have made, making their mistakes visible, which is expected to increase their independence, as they can correct their own mistakes and better understand why they are wrong (Ebbels, 2007).

The literature on metalinguistic intervention ranges from uncontrolled case studies to randomized controlled group studies in various clinical settings and reports on varied research designs (see Ebbels 2014, for a review). Most studies used colour codes to help children in structuring sentences and identifying specific syntactic elements. These approaches are based on 'Colourful Semantics' (Bryan, 1997) that was developed to highlight the argument structure of sentences.

Several uncontrolled case studies using metalinguistic intervention can be found in the literature. For example, one case study using the Colourful Semantics system reported significant progress in content and structure of expressive language of two children with receptive and expressive language difficulties (Spooner, 2002). However, in another study using this system, only one of two children with SLI made some progress after a one-year intervention (Guendouzi, 2003).

Levy and Friedman (2009) studied the effectiveness of an intervention combining elements of Colourful Semantics (Bryan, 1997) and the Shape Coding Scheme developed by Ebbels

(2007) on the comprehension and production of structures involving syntactic movement in a 12-year old boy with severe SLI. Written and oral exercises were used to teach syntactic movement explicitly in various syntactic structures. Improvement was seen directly after treatment and 10 months after.

In a multiple case study involving four 11- and 12-year-old children with severe receptive and expressive SLI, Ebbels and van der Lely (2001) investigated the efficacy of Shape Coding for improving production and comprehension of passives and *wh*-questions. Results showed that the first objective, i.e., improving the use of passives, was reached for three out of four children. Furthermore, progress was seen on production and comprehension of *wh*-questions post-therapy, but gains were not maintained for most of the children at follow-up 10 weeks after therapy (Ebbels & van der Lely, 2001).

In the study of Kulkarni, Pring, and Ebbels (2013) two 8-year old children were treated with Shape Coding to improve their use of past tense in both structured tasks and conversation. One of the children improved on the structured tasks, but needed a generalization intervention before gains in conversation could be observed. The other child made modest gains on both structured tasks and conversation without recourse to the generalization therapy.

A limited number of studies on the effects of metalinguistic approaches used (quasi-) experimental group designs. Bolderson, Dosanjh, Milligan, Pring, and Chiat (2011) found progress after therapy using Colourful Semantics (Bryan, 1997) in both comprehension and production in 5- and 6-year old children with expressive difficulties, which contrasted with absence of change during a (preceding?)_baseline period. Another group study (Hirschman, 2000) involved a total of 67 children with SLI in two groups (with mean ages 9;4 and 10;6 years) who all? received 55 30 minute group therapy sessions of metalinguistic training in a classroom setting during a nine month period. These children were compared to a non-treated reference group of children with SLI matched on grade level. The metalinguistic training aimed at improving the use of complex sentences, utilizing written language and illustrations. A comparison of pre-therapy and post-therapy test scores showed that the use of complex sentences improved in oral and written language (Hirschman, 2000).

In another study, Shape Coding was used to enhance the comprehension of dative forms and comparative questions, as well as the use of past tense in written work (Ebbels, 2007). Nine pupils (aged between 11 and 13 years) took part; six of these children made progress, but the method was not effective for all children for all goals (Ebbels, 2007).

To date, two randomized controlled trials (RCT) have been published that target individual metalinguistic therapy approaches. The first RCT investigated the production of verb argument structure in 27 children with SLI (aged 11;0 - 16;1) with a pre-therapy, post-therapy, and follow-up assessment (Ebbels et al., 2007). The children were randomly assigned to three conditions, viz., Shape Coding, verb semantic therapy, or a usual care control therapy. Both the Shape Coding approach and the semantic therapy yielded significant progress, which was also maintained after three months (Ebbels et al., 2007).

The second RCT study used a waiting list condition and focused on comprehension of coordinating conjunctions (Ebbels et al., 2014). Fourteen children (aged 11;3 - 16;1) with receptive and expressive language impairment received eight 30-minutes individual sessions of explicit teaching with visual support of the Shape Coding system. Results showed Shape Coding therapy led to a significant improvement in comprehension of the targeted conjunctions as well as on the Test of Reception of Grammar (TROG-2; Bishop, 2003), but not on a test of passives (Ebbels et al., 2014).

In conclusion, studies on metalinguistic intervention for children with SLI aged 8 years and over, report favourable results for a wide array of different grammatical targets. However, while there is a growing body of evidence in research on interventions for grammar in school-age children with SLI, much work still has to be done. For example, it is still unclear which grammatical targets are most appropriate at what ages, whether individual intervention is equally effective as group therapy, whether digital media (apps) can contribute to the efficacy of intervention, and whether metalinguistic therapy also works without deploying written language.

Multimodal learning

The metalinguistic approaches discussed so far all used two-dimensional visual support systems consisting of different shapes and colours. Written language also formed an important component of the interventions used with older children with SLI. (e.g., Hirschman, 2000; Levy & Friedman, 2009). However, a substantial proportion of children with SLI experience problems in reading and spelling (McArthur, Hogben, Edwards, Heath & Mengler, 2000; van Weerdenburg, Verhoeven, Bosman, & van Balkom, 2011). It is likely that for such children, employing reading activities in therapy may be more of a hindrance than a help.

For the present study, we searched for a dynamic, multimodal approach that would not only make use of the visual and auditory channels, but that would also employ the tactile/kinesthetic and motor systems. According to Shams and Seitz (2008), the human brain has evolved to develop, learn and operate optimally in multimodal environments. Sensori-motor engagement raises the level of active participation in the children and may also enhance their enjoyment and motivation for therapy (Sankey, Birch, & Gardiner, 2010). Therefore, an intervention approach encompassing a tactile/kinesthetic and motor component was expected to effectively support language learning. In education, multimodal training approaches are not new at all (see, e.g., Montessori, 1912, 1949). In fact, what Montessori achieved through careful observation of child development is now substantiated by research. The processing of information entering the cognitive system through multiple channels helps to circumvent the limited processing capabilities of the individual channels (Clark & Paivio, 1991). Consequently, a greater total of information can be processed when shared between multiple senses (Birsh, 2005).

A multimodal and metalinguistic intervention approach in which language is represented by manipulable items was found in the 'Grammar in Form and Colour' programme, originally developed for Danish by K. Thyme to remedy grammatical problems in children with severe

hearing impairment (K. Thyme, personal communication, December 8, 2010). ‘Grammar in Form and Colour’ uses Lego® bricks as representations of grammatical structures. Word classes and functional morphemes are represented by bricks of specific colours, shapes, and sizes. By manipulating the bricks and laying them out sequentially on a base plate, children learn to (literally) build and expand sentences.

Thyme's intervention programme was adapted for Dutch by van Geel (1973), but interest in the approach has gradually waned, and it has not been developed further. We adopted the programme, and expanded it with new codes that enabled representation of complex sentences, notably relative clauses and relative pronouns. Because of the changes to the original intervention method, the new version was renamed ‘MetaTaal’, a compound of the Dutch words for ‘metalinguistic’ and ‘language’.

Relative clauses and (Dutch) SLI

Results have shown that children with SLI fail on relative clause (RC) comprehension and production at ages beyond the normal age of relative clause acquisition in different languages, such as English (Adams, 1990; Schuele & Nicholls, 2000), Italian (Cipriani, Bottari, Chilosi & Pfanner, 1998), Danish (Jensen de López, Sundahl Olson, & Chondrogianni, 2014), Hebrew (Friedmann & Novogrodsky, 2004), Greek (Stavrakaki, 2001), Swedish (Håkansson & Hansson, 2000), and Dutch (Zwitserlood, 2014). Several explanations have been proposed to account for this phenomenon. It is beyond the limits of this study to discuss these in any detail. Generally speaking, nativist approaches (e.g., Van der Lely, Rosen, & McClelland, 1998; Friedman & Novogrodsky, 2004) argue that children with SLI have a specific deficit in syntax that prevents them from building the grammatical structure underlying RCs. By contrast, processing hypotheses pose that the difficulty children with SLI have with RCs is due to deficits of the processing mechanisms underlying language perception or production. Cases have been made for severe working memory limitations (e.g., Deevy & Leonard, 2004; Hestvik, Schwartz, & Tornqvist, 2010), reduced attentional capacity (Finneran, Francis, & Leonard, 2009), general processing speed (Leonard, Weismer, Miller, Francis, Tomblin, & Kail, 2007) and executive function (Im-Bolter, Johnson, & Pascual-Leone, 2006). Recently, usage-based approaches to language acquisition have linked the RC acquisition trajectory in typically developing children to quantitative properties of the input (e.g., Brandt, Kidd, Lieven, & Tomasello, 2009). However, these approaches have so far not been brought to bear on the delay of RC acquisition in children with SLI.

In order to appreciate the difficulties children with SLI experience with relative clauses, some elaboration on Dutch relative clauses is appropriate at this point. A relative clause can be defined as a subordinate clause that modifies a (head) noun or a noun phrase in an adjacent main clause. The classification of relative clauses is based on two structural features. The first of these is the syntactic role of the head, i.e., the main clause element that is modified by the relative clause, which mostly is either subject (S) or object (O). The second feature is the syntactic role of the gap, i.e., the element that is gapped or relativized inside the relative clause, which is either the subject or object of the relative clause. The taxonomy put forward by Goodluck and Tavakolian (1982) has been widely used in

developmental studies on relative clauses and involves four different relative clause types. The sentences in (1) to (4) give an example of each type.

- (1) The boy (S) [that (S) drank the juice] fell ill. (SS)
- (2) Mary kissed the boy (O) [that (S) brought the flowers]. (OS)
- (3) The boy (S) [*that* (O) John kicked] ran away. (SO)
- (4) John kicked the boy (O) [*that* (O) Mary knew]. (OO)

The sentences in (1) and (2) are classified as subject relative clauses, because the relative pronoun takes the subject role. Sentences in the examples (3) and (4) are defined as object relative clauses, because the relative pronoun takes the object role. Relative clauses can furthermore be classified on the basis of their position within the sentence, and can either be center-embedded (examples 1 and 3) or right-branching (examples 2 and 4). In the center-embedded versions, there is a distance (non-local dependency) between the subject and the finite verb of the main clause. This distance is determined by the length of the relative clause. From a processing view, sentences containing (longer) center-embedded clauses are harder to process because of these non-local dependencies (Just & Carpenter, 1992; Gibson, 1998).

Dutch and English relative clauses are different in a number of grammatical aspects. A first difference concerns the relative pronoun. In English, the relative pronoun in object relative clauses (in italics in examples 3 and 4) is optional, whereas in Dutch it is obligatory. Second, Dutch relative clauses require gender agreement between the head noun and the relative pronoun. The relative pronoun can either take common gender form '*die*', or neuter gender form '*dat*'. A third difference between Dutch and English relative clauses relates to their verb placement requirements. Dutch is a so-called SOV + verb-second language. The finite verb always takes second position in main clauses, but appears in clause-final position in subordinate (relative) clauses. A fourth contrast is that, because of these verb placement requirements, Dutch relative clauses with animate subjects and objects are not disambiguated by word order, as is the case in English. Such clauses can remain ambiguous between a subject relative clause reading and an object relative clause reading (example 5). Disambiguation can be effected by morpho-syntactic means (e.g., subject-verb agreement, as in example 6), or – defeasibly – by pragmatic plausibility (example 7).

- (5) Het konijntje SING (S), dat (S or O) de jager SING (S or O) ziet SING, zit in het gras.
 The rabbit (S), that (S) sees the hunter, sits in the grass. (SS), or:
 The rabbit (S), (that) (O) the hunter sees, sits in the grass. (SO)
- (6) Het konijntje SING (S), dat (O) de jagers PLU (S) zien PLU, zit in het gras.
 The rabbit (that) the hunters see, sits in the grass.
- (7) Het konijntje dat de jager op de korrel heeft, zit in het gras.
 The rabbit (S) (that) the hunter draws a bead on, sits in the grass.

In summary, (Dutch) relative clauses can be regarded as complex grammatical structures with characteristics such as (1) variety in types of relative clauses; (2) gender agreement between relative pronoun and the relativized noun; (3) different verb placement requirements in main and subordinate clauses; and (4) non-local dependencies associated to center-embedded versions.

In view of their complexity, targeting relative clauses in an intervention study is challenging. If we should find that school-aged children with SLI can learn to use and understand relative clauses through the 'MetaTaal' programme, there will be all the more reason to adopt this approach for children with persistent language difficulties older than 8 or 9 years.

The present study

In the present study, a concurrent within-subjects multiple-baseline design was used. In this quasi-experimental design, the children with SLI were tested three times on criterion-referenced tasks during three subsequent monthly measurements (T1, T2, and T3) prior to the treatment. These tasks were especially constructed for this study to test relative clause production and comprehension. After the three months of baseline testing, treatment was started for all children. Children were assessed directly after treatment at T4, and 12 weeks after the last therapy session at T5.

An advantage of this approach is that it moderates several threats to validity, history effects in particular (Carr, 2005; Harris & Jenson, 1985). However, this quasi-experimental design does not meet the requirements of a randomized controlled trial. It only involved a comparison of no-treatment (i.e., T1, T2, and T3) with treatment (i.e., T4 and T5) conditions and the intervention procedures and goal were limited. Therefore, it should be regarded as an early efficacy study (Fey & Finestack, 2009).

In this multiple-baseline design, the participants can be regarded to act as their own controls. Therefore, we reasoned that if the school-aged children with SLI did not improve in their production and comprehension of relative clauses during the pre-therapy baseline period, and if their scores increased post-therapy, this increase should be attributed to the 'MetaTaal' intervention. Furthermore, maintained improvement at a retention measurement administered 12 weeks later without providing any further intervention would indicate that the children had effectively improved on relative clause use.

Method

Participants

A total of 13 monolingual Dutch speaking children with SLI were included. The descriptives of the participants can be found in Table 1. All children were admitted to a special school for children with language impairments after extensive clinical and psychometric examination by an independent team of specialists (i.e., a psychologist, a speech-language therapist, an educational specialist and an audiologist). The admission to Dutch special education is only valid for three years, and children have to be reassessed within this time

period. The criteria for admission to special education entail that children have to be diagnosed as having SLI.

This implies that: 1) The children have to score -1.5 sd on standardized tests for at least two out of four language domains (speech, auditory processing, lexical-semantic knowledge, morpho-syntactic knowledge). Children answering to this criterion may or may not have additional pragmatic problems, which are weighed additionally by the admission committee. 2) Grades at math and reading skills also have to be poor (lowest 10%), and 3) the language problems must be persistent, which in practice means that six months of language therapy had not been enough not produce sufficient progress on language tests. Furthermore, the children with SLI in this study had non-verbal cognitive abilities within normal limits and no diagnosed comorbidity such as ADHD or autism spectrum disorders. All children were tested by the school therapists on a yearly basis; the language scores in Table 1 refer to the last assessment ?prior to the onset of the intervention?.

The participating children had a mean age of 11;2 years (standard deviation 1;1 years, age range 9;3 – 12;8 years). Around this age the children supposedly have acquired reading skills, and their metalinguistic awareness is developed to such an extent that they are able to reflect on grammatical features of language. It must be noted that one child dropped out after three therapy sessions because of poor cognitive skills. Her non-verbal IQ appeared to be 76 on retesting, even though it had been within the normal range at the initial selection. During therapy, she was not able to make the abstraction from words to Lego® bricks. Consequently, 12 children (8 boys and 4 girls) completed all measurements and all sessions of the intervention programme.

Procedure

This study was reviewed and approved by the Dutch Central Committee on Research Involving Human Subjects (CCMO; *Centrale Commissie Mensgebonden Onderzoek*). Informed written consent was obtained from the parents of all participating children. To minimize the effects of various extra-experimental variables (e.g., different speech therapists involved, therapy settings, school curriculum differences, and period in the school year) we chose to confine our study to just one school, one therapist, and one period. This decision limited the number of children that could participate, and consequently ruled out the inclusion of a control group. We explored the possibility of a waiting-list control group, but this was not in accordance with the rules of the ethics committee.

Comprehensive manuals and protocols were constructed for the assessments and therapy programme and they were followed strictly. A concurrent within-subjects multiple-baseline design was used, with three baseline measurements (T1, T2, and T3) prior to the treatment and two measurements after treatment, i.e., T4 directly after treatment and a retention measurement 12 weeks after the last therapy session (T5).

The assessment of 6 children at T1 was carried out by the speech therapist who also delivered the intervention. Two research assistants tested the remaining 7 children at T1 and all children in the four subsequent measurements. These assistants were experienced clinical linguists who were not involved in either the school or the intervention programme. The

assistants scored the tasks and scores were checked and analysed afterwards by the experimenter. All treatments were delivered by one and the same speech therapist and during the entire testing and treatment period, this speech therapist remained blind to the test results.

During intervention, the speech therapist, who was also a clinical linguist and researcher, kept a logbook, which contained information on all treatment sessions for all participating children. After each session, the speech therapist and one of the researchers (RZ) discussed the information in the logbook in order to make sure that protocol was followed. After the intervention programme was completed, the children did not receive any further speech/language therapy. The retention assessment was conducted by a research assistant 12 weeks after the last therapy session. Importantly, relative clauses were not part of the school curriculum for the duration of the intervention study.

Materials

Description and scoring of the relative clause tasks—Standardized language tests could not be used to measure the progress of relative clause use, because these tests do not contain enough items assessing relative clauses and are not sensitive enough. Therefore, specific, dedicated tasks were constructed to assess the relative clause types that were targeted in this intervention study. The six tasks are described in detail below. Each example of the tasks starts with the instruction of the investigator (IN), followed by the target response (TR) expected from the children, in italics.

Task 1: Right-branching OS relative clause completion (10 items): In this elicited production task, adapted from Novogrodsky and Friedmann (2006), the children were instructed to complete sentences after a verbal prompt was presented, as illustrated in example (7) below. Test items were adjusted to participant gender (example 7). Responses were scored as correct when a complete sentence containing a relative clause was produced, and the relative clause contained a relative pronoun and an inflected verb in clause final position. All responses that did not meet these criteria were classified as incorrect.

(7) IN: Eén jongen (meisje) koopt een lolly en één jongen koopt een ijsje.

Welk(e) jongen (meisje) zou jij willen zijn?

Begin je antwoord met: Ik kies de jongen (het meisje)

TR: *die (dat) de lolly koopt.*

IN: One boy (girl) buys a lollipop and one boy (girl) buys an ice cream.

Which boy (girl) would you like to be?

Start your answer with: I choose the boy (the girl).....

TR: *who the lollipop buys.* ("I choose the boy who buys the lollipop").

Task 2: Production of center-embedded SS relative clauses (10 items): Because center-embedded relative clauses are difficult to elicit, this task contained test items with 3 written short sentences (example 8). From these three short sentences the children had to construct a

sentence with an embedded SS relative clause. The sentences were first read aloud together by the child and the research assistant, while the research assistant pointed at the words in synchrony with reading them. The children were instructed to use all bold printed words (verbs) and to not use the conjunction ‘en’ (and). Responses were scored as correct when a complete complex sentence containing a center-embedded relative clause was produced. The relative clause had to contain a relative pronoun and an inflected verb in clause final position. All responses that did not meet these criteria were classified as incorrect.

(8) IN: Er is een chauffeur. / Hij **draagt** een hoed. / Hij **zit** in de auto.

Begin je zin met: De chauffeur....

TR: *die een hoed draagt, zit in de auto.*

IN: There is a driver. / He **wears** a hat. / He **sits** in the car.

Start your sentence with: The driver...

TR: *who a hat wears, sits in the car.* (“The driver who wears a hat, sits in the car”).

Task 3: Recreating OS and SS relative clauses (16 items): This task was based on the subtest ‘Sentence Assembly’ from the Dutch version of the CELF-4 (Semel, Wiig, & Secord, 2008). The different parts of the sentences were visually presented in frames in a scrambled and ungrammatical order (example 9). The test items were read aloud by the child and investigator. The children were invited to reconstruct the sentences and were instructed to start with the underlined word(s), which also had a capital letter. Responses were scored as correct when the children produced a grammatical sentence containing a relative clause pattern.

(9)

Stefanie	dorst	drinkt water	die	heeft
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IN: Begin je zin met: Stefanie....

TR: *die dorst heeft, drinkt water.*

IN: Start your sentence with: Stefanie ...

TR: *who thirst has, drinks water* (“Stefanie who is thirsty, drinks water”).

Tasks 4 and 5: Sentence repetition (short: 12 items; long: 15 items): Two sets of sentences containing both OS and SS type relative clauses had to be repeated by the children. Working memory limitations are often seen in children with SLI. In order to investigate the role of sentence length in a repetition task, two different sets of sentences with OS and SS type relative clauses were constructed. The first set contained twelve 7-word sentences and the second set contained fifteen 12-word sentences. The examples (10) and (11) show the two relative clause types presented in the 7-word condition. Responses were scored as correct when a relative clause pattern was produced. The relative clause had to contain a relative pronoun and an inflected verb in clause final position.

(10) Hij ziet een vrouw die cake eet. (7 words, OS type)

He sees a woman who cake eats. (He sees a woman who eats cake.)

- (11) De clown, die ballonnen opblaast, ziet Marloes. (7 words, SS type)

The clown, who balloons blows up, sees Marloes. (The clown who blows up balloons, sees Marloes.)

Task 6: Relative clause comprehension (28 items): In this picture selection task, sentences containing SS and OS relative clauses were presented to the participants. The children had to select the correct picture from a set of four pictures. The images were full colour photographs of scenes with Playmobil® figurines and props. Figure 1 shows one of the test items. The accompanying test item of an embedded SS type relative clause is shown in example (12). Responses were scored as correct when the child selected the correct picture.

- (12) De jongen die naar de kinderen wijst, draagt een pet.

The boy that to the children points, wears a cap.

(“The boy who points to the children wears a cap”).

For all tasks, two versions (A and B) were constructed, which were alternated, in order to suppress a possible learning effect from multiple presentations of the tasks. The items in the A and B versions of each test were carefully matched with regard to lexical content, word order, and, where pictures were used, the order in which these were presented. For instance, the italicized nouns in a test sentence changed places (one boy plays the *violin*, the other boy plays the *flute*), or high frequency nouns and verbs differed between versions (*boy* becomes *girl*, or *writes a letter* becomes *types a letter*). In the comprehension task, either the order of the four pictures differed between the A and B versions, or the word order in the test sentence was changed (*The boy who points to the children wears a cap* versus *The children who point to the boy wear a cap*, see Figure 1, example 12).

The tasks were always administered in the same order; the three production tasks were presented first, followed by the two sentence repetition tasks and the comprehension task. All tasks contained two or three practice items depending on the difficulty of the task.

Intervention programme—The children received a total of 10 individual therapy sessions lasting 30 minutes each, twice a week during 5 weeks. All therapy sessions were protocolled in a therapy manual which was followed strictly by the speech therapist who delivered the intervention. An example of a MetaTaal therapy session is given in Appendix A. First, the children were introduced to the concept that words would be represented by Lego® bricks in different shapes, sizes and colours. The children also practised with exercises aimed at the identification of different clause types and conjunctions in written and spoken language. When the concepts and procedures of the intervention programme were understood, the children started building simple declarative sentences consisting of a subject, verb and object. Subsequently, more elements such as prepositional phrases, plural nouns and subject-verb agreement were introduced.

The next step was to build coordinated sentences by connecting two main clauses with an arched brick (a bridge). An example of a coordinated sentence built with Lego® bricks can be seen in Figure 2. Next, the children were instructed that this sentence could be truncated by deleting the subject of the second main clause (which was identical to the subject of the

first clause). This operation resulted in a sentence containing coordination with reduction, as is illustrated in Figure 3. Obviously, the terms ‘coordination’ and ‘subordination’ were not used with the children. Instead, these sentences were called ‘*bruggetjeszinnen*’ (bridge sentences). When the children performed well on building coordinated sentences, right-branching (OS) subject relative clauses were introduced. As can be seen in Figure 4, these relative clauses were built on the base plate on a lower level than the main clause. The bridge was used to connect the main clause with the relative clause. The last step in the intervention programme was reserved for building center-embedded (SS) subject relative clauses. Two bridges were used to express subordination and center-embedding. The first bridge connected the main clause to the lower relative clause. A second bridge was needed to connect the relative clause to the second part of the main clause again. This extra bridge was called a ‘comma bridge’, and was placed between the two inflected verbs of the relative clause and the main clause. An example of a center-embedded (SS) type relative clause can be seen in Figure 5. The ‘comma bridge’ was created by stacking a small corner brick on top of an arched brick. The children easily understand this concept, because in running speech it is natural to pause at that point in the sentence, while in written text a comma is often placed between two inflected verbs.

The speech therapist delivering the intervention checked during sessions and retrospective at the start of a new session, whether the child was ready for the next step in the program, or that further rehearsal was necessary. During the intervention sessions, the children did not have to memorise the functions of the different colours, bricks and bridges. They always had a crib sheet with pictures of all the bricks and examples of their functions at hand (see Appendix B). Instruction was mostly oral; minor reading and writing activities were included only when necessary, e.g. in exercises where the children had to write the relative pronoun *die* or *dat* between printed sentences. While building sentences, the children were free to add, move and remove bricks. Several sentences could be constructed on the base plate below one another, so that they could be easily compared. Another option was to check for differences between sentences built by the child and by the therapist. Conversations, short stories and pictures were used to elicit relative clauses during therapy. Each therapy session also had a game activity to consolidate the target structures. The children did not practice relative clauses in the classroom and no homework was given.

Results

The scores and significant differences between measurements on the repeated baseline, post-therapy, and retention measurements of the six relative clause tasks are presented in Table 2. Because the participant group was small and the data violated the assumptions for GLM analyses on repeated measures, non-parametric tests were used. Differences between the five measurement points were analysed with Friedman's non-parametric ANOVA, using the exact statistic. When Friedman's tests reached significance, subsequent post-hoc Wilcoxon signed rank tests were used to test differences between time points (exact statistic, two-tailed). A Bonferroni correction was applied for all post-hoc tests, as a result of which all effects are reported at a $p = .008$ level of significance ($p = .05/6$ comparisons). The effect size r was computed by dividing the Z-score (of the scores of the particular tasks) by the

square root of the total observations (Field, 2009). An effect size r from .10 to .30 represents a small effect, from .30 to .50 a medium effect and beyond .50 a large effect.

Relative clause production

On the three relative clause production tasks a clear pattern was seen with no pre-therapy progress between T1 and T2, T2 and T3, and T1 and T3. On two tasks, progress was found post-therapy between T3 and T4 and between T3 and T5 (see Table 2), which was also maintained at retention measurement.

Regarding the *OS Completion task*, analysis with Friedman's ANOVA showed that the scores of the children between baseline measurements, pre- and post-therapy tests and the final retention measurement did change significantly ($\chi^2(4) = 20.72$ and $p < .001$). However, Post-hoc Wilcoxon tests indicated that no significant difference was found between T1 (*Median (Mdn)* = 6.50) and T2 (*Mdn* = 8.50) ($Z = -1.86$, $p = .070$, $r = -0.38$), between T2 (*Mdn* = 8.50) and T3 (*Mdn* = 8.00) ($Z = -.23$, $p = .855$, $r = -0.05$), and between T1 (*Mdn* = 6.50) and T3 (*Mdn* = 8.00) ($Z = -2.41$, $p = .014$, $r = -0.49$). Post-therapy the difference was not significant between T3 (*Mdn* = 8.00) and T4 (*Mdn* = 10.00) ($Z = -2.41$, $p = .016$, $r = -0.49$) and between T4 (*Mdn* = 10.00) and T5 (*Mdn* = 9.00) ($Z = -1.93$, $p = .094$, $r = -0.39$). The difference between the last baseline test (T3) and the retention measurement (T5) was also not significant ($Z = -1.93$, $p = .094$, $r = -0.39$). In sum, on the *OS Completion task* no significant gains were found between the measurements. Further inspection on the individual trajectories (see Figure C1 in Appendix C) revealed that between T1 and T3 some children first showed some improvement (at T2) and then decline (at T3), whereas others showed first decline (at T2) and then improvement (at T3). However, after T3 none of the children showed a decline: they either had the same or higher scores on T4 and T5 (as compared to T3).

With respect to the *SS Composition task*, Friedman's ANOVA returned a significant difference between measurements, $\chi^2(4) = 31.40$, $p < .001$. Post-hoc Wilcoxon tests indicated that no significant difference was found between T1 (*Mdn* = .00) and T2 (*Mdn* = .50) ($Z = -1.68$, $p = .125$, $r = -0.34$), between T2 (*Mdn* = .50) and T3 (*Mdn* = .00) ($Z = .00$, $p = 1.00$, $r = -0.00$), and between T1 (*Mdn* = .00) and T3 (*Mdn* = .00) ($Z = -2.41$, $p = .014$, $r = -0.49$). Post-therapy, the difference was significant between T3 (*Mdn* = .00) and T4 (*Mdn* = 9.50) with $Z = -2.83$, $p = .002$ and $r = -0.58$. The difference in scores between T4 (*Mdn* = 9.50) and T5 (*Mdn* = 9.50) was not significant, with $Z = -.264$, $p = .984$, and $r = -0.05$. The difference between the last baseline test (T3) and the retention measurement (T5) was significant ($Z = -2.67$, $p = .004$, $r = -0.55$). Thus, on the *SS Composition task*, the children did not improve between baseline measurements, but post-therapy significant gains were found that were maintained at retention measurement. Further inspection on the individual trajectories (see Figure C2 in Appendix C) revealed a rather diffuse pattern of scores between T1 and T3. However, between T3 and T4, all but one of the children made progress on this task and for most children, this progress was maintained at T5.

On the relative clause *Recreation task*, Friedman's ANOVA yielded significant differences over time, $\chi^2(4) = 34.40$, $p < .001$. Post-hoc Wilcoxon tests indicated that no significant difference was found between T1 (*Mdn* = 7.00) and T2 (*Mdn* = 7.50) ($Z = -1.58$, $p = .134$, r

= -0.32), between T2 ($Mdn = 7.50$) and T3 ($Mdn = 10.00$) ($Z = -1.36$, $p = .203$, $r = -0.27$), and between T1 ($Mdn = 7.00$) and T3 ($Mdn = 10.00$) ($Z = -2.32$, $p = .018$, $r = -0.47$). Post-therapy, the difference was significant between T3 ($Mdn = 10.00$) and T4 ($Mdn = 11.50$) with $Z = -2.67$, $p = .006$, and $r = -0.54$. The difference in scores directly post-therapy (T4, $Mdn = 11.50$) and the retention measurement (T5, $Mdn = 12.00$) was not significant ($Z = -1.72$, $p = .113$, $r = -0.35$). The difference between the last baseline test (T3) and the retention measurement (T5) was significant ($Z = -2.96$, $p = .001$, $r = -0.60$). Thus, on the *Recreation task*, the children did not improve between baseline measurements, but gains were significant post-therapy and were maintained 12 weeks later. A closer look at the individual trajectories (see Figure C3 in Appendix C) revealed that the children scored relatively stable between T1 and T3. Furthermore, progress between T3 and T4 was small per child, but nonetheless significant.

Relative clause repetition

Two sentence repetition tasks were used. In the first sentence repetition task, sentences containing seven words were used. On this task, no differences were found between pairs of measurements. Results of the second task containing sentences with twelve words, showed a more complicated pattern.

On the first *Repetition task (7 word sentences)*, analysis with Friedman's ANOVA showed that the children obtained significantly different scores over time, $\chi^2(4) = 13.08$, $p = .006$. Post-hoc Wilcoxon tests yielded no significant difference between T1 ($Mdn = 12.00$) and T2 ($Mdn = 11.50$) ($Z = -1.51$, $p = .250$, and $r = -0.31$), between T2 ($Mdn = 11.50$) and T3 ($Mdn = 12.00$) ($Z = -2.00$, $p = .125$, and $r = -0.41$), and between T1 ($Mdn = 12.00$) and T3 ($Mdn = 12.00$) ($Z = -.82$, $p = .750$, $r = -0.17$). Post-therapy, the difference was not significant between T3 ($Mdn = 12.00$) and T4 ($Mdn = 11.00$) ($Z = -1.73$, $p = .250$, $r = -0.35$). The difference between post-therapy scores (T4, $Mdn = 11.00$) and retention measurement (T5, $Mdn = 12.00$) was also not significant, with $Z = -2.45$, $p = .031$, and $r = -0.50$. The difference between the last baseline test (T3) and the retention measurement (T5) was not significant ($Z = -1.73$, $p = .250$, $r = -0.35$). At further inspection on the individual scores (see Figure C4 in Appendix C) five out of 12 children appeared to have extreme ceiling effects with maximum scores at all measurements and the rest of the children also showed ceiling effects.

On the second *Repetition task (12 word sentences)*, Friedman's ANOVA yielded significant differences, $\chi^2(4) = 17.51$, $p = .001$. Post-hoc Wilcoxon tests indicated that no significant difference was found between T1 ($Mdn = 11.00$) and T2 ($Mdn = 12.00$) ($Z = -.54$, $p = .652$, and $r = -0.11$), between T2 ($Mdn = 12.00$) and T3 ($Mdn = 11.00$) ($Z = -.30$, $p = .848$, and $r = -0.06$), and between T1 ($Mdn = 11.00$) and T3 ($Mdn = 11.00$) ($Z = -1.00$, $p = .359$, and $r = -0.20$). Post-therapy, the difference was not significant between T3 ($Mdn = 11.00$) and T4 ($Mdn = 10.50$) ($Z = -2.16$, $p = .047$, $r = -0.44$), and between T4 ($Mdn = 10.50$) and T5 ($Mdn = 13.00$) ($Z = -2.14$, $p = .043$, $r = -0.44$). However, the difference between the last baseline test (T3) and the retention measurement (T5) was significant ($Z = -2.58$, $p = .008$, $r = -0.53$). Inspection of the scores per child (see Figure C5 in Appendix C) revealed that most

of the individual growth trajectories were relatively flat, but that a trend of limited progress over all measurements could be seen.

Relative clause comprehension

The relative clause comprehension tasks showed that no differences were found between pairs of measurements. Friedman's ANOVA showed a significant difference over time, $\chi^2(4) = 15.16, p = .002$. Post-hoc Wilcoxon tests returned no significant difference between T1 ($Mdn = 19.50$) and T2 ($Mdn = 19.00$) ($Z = -1.28, p = .236, r = -0.26$), between T2 ($Mdn = 19.00$) and T3 ($Mdn = 21.00$) ($Z = -2.32, p = .018, r = -0.47$), and between T1 ($Mdn = 19.50$) and T3 ($Mdn = 21.00$) ($Z = -1.56, p = .124, r = -0.32$). Post therapy, no significant differences were found between T3 ($Mdn = 21.00$) and T4 ($Mdn = 20.50$) ($Z = -1.01, p = .355, r = -0.21$), between T4 ($Mdn = 20.50$) and T5 ($Mdn = 22.00$) ($Z = -1.86, p = .067, r = -0.38$), and between the last baseline test (T3) and the retention measurement (T5) ($Z = -.71, p = .518, r = -0.14$). Finally, a closer look at the individual scores on each measurement showed that between T1 and T2 children did not progress, but that between T2 and T3 progress was made by most of the children, followed by a decrease in scores between T3 and T4. However, these trends were not significant.

Discussion

The purpose of this study was to examine the efficacy of the metalinguistic 'MetaTaal' approach for school-age children with SLI. This intervention study followed a repeated-baseline design and targeted complex sentences comprising OS and SS type subject-relative clauses. Relative clauses were selected as target since school-age children with SLI are known to have persistent difficulties with these types of complex structures. In order to be effective, we expected that children's performance on tests assessing their ability to produce and comprehend sentences comprising relative clauses would improve significantly immediately after the intervention, and that this improvement would be maintained 12 weeks after the intervention had been completed.

In order to evaluate the effectiveness of the intervention, we first examined whether spontaneous growth in relative clause production and comprehension occurred prior to the onset of therapy. Therefore, three baseline measurements were executed pre-therapy once a month. The results showed that the children did not improve on any of the relative clause tasks during baseline measurements. However, significant gains were found on two of the three production tests (i.e., the SS Composition and the Recreation tasks) directly post-therapy (T4). These gains were also maintained at the retention measurement twelve weeks later (T5) when scores on T3 and T5 were compared. On the 12-word Sentence repetition task, a significant improvement was found between scores on T3 and T5. However, on the other three tasks (i.e., OS Completion, 7-word Sentence repetition, and Comprehension tasks) no significant differences were found. These results partly confirm the efficacy of the 'MetaTaal' programme. Significant improvement was observed for relative clause production, but not for comprehension. In the following paragraphs, these differences in results and some methodological issues will be discussed.

The first issue that needs to be addressed is whether learning effects due to the repeated administration of the tasks could have contributed to the observed gains. We suppose that multiple exposure to sentence repetition tasks and a picture selection task probably would not lead to learning effects. Both tasks are relatively simple and not much learning can be expected to occur from repeating sentences and picture pointing. However, the production tasks were more complex and repetition of these tasks may have produced a learning effect. Nonetheless, in none of these tasks significant changes were found during baseline, although upward trends were observed (see Appendix C). This trend was most apparent for the OS Completion task. For the SS Composition and the Recreation task more variation in score patterns was seen (Appendix C). Some children did improve during baseline measurements, but in other children scores fell off, which makes the presence of an overall learning effect less obvious.

Next, the lack of improvement on the Comprehension task needs to be considered. On this task, scores remained well below ceiling in all measurements. Although relative clause production was the main component of the intervention, it is conceivable that a metalinguistic approach aimed at explicit learning of linguistic knowledge would have an effect on comprehension. Two possible explanations for not finding such an improvement come to mind. First, the comprehension task may have been too complex for the children. The children had to retain complex sentences with relative clauses in working memory and compare these sentences to four different pictures. Moreover, the sentences in the comprehension task were also longer than those used in the production tasks. Second, it may have been the case that five hours of therapy focused at relative clause production was not enough to cause significant progress on the comprehension of relative clauses. Our result contrasts with Camarata, Nelson, Gillum, and Camarata (2009), who found that children with SLI made significant gains in language comprehension when exposed to language intervention that was focused on production. However, in Camarata et al. (2009), intervention amounted to 24 hours in 12 weeks, which is almost five times the amount of intervention provided in our study.

Another methodological issue concerns the use of two separate versions of the five relative clause tasks. In the materials section, we explained that A and B versions were administered in order to minimise possible learning effects and that both versions were only slightly different. We did not validate the tasks and did not compare both versions beforehand. However, the two versions can be compared post hoc, because the A version was administered at T1, T3, and T5 and the B version at T2 and T4. No significant differences were found for all five tasks between T1 (A) and T2 (B), as well as between T4 (B) and T5 (A). Therefore we assume that the two measures can be considered parallel task versions. The comparison of the two versions between T3 (A) and T4 (B) cannot be made, because these time points were the pre- and post-therapy measurements.

Furthermore, it is important to have a closer look at the performance of the children on the two sentence repetition tasks. The answers of the children were scored as correct when they fulfilled the minimum requirements (i.e., realization of a relative pronoun and correct verb placement in the relative clause). However, the children made many omission and substitution errors, even though they mostly succeeded in correctly conveying the meaning

of the sentences. For instance, a phrase such as “the clown who has a balloon” was changed into “the clown with a balloon”. Apparently, the children were able to process the meaning of the sentences correctly, but failed to reconstruct the grammatical structure. This finding is also in line with the very poor results of the children on the CELF-4-NL subtest Recalling Sentences (see Table 1). Moreover, on the 12-word repetition task, the children improved between T3 and T5. Although no effect was seen directly post-therapy, the children scored significantly higher on T5 (retention) than on pre-therapy measures after a period of 12 weeks with no further training. This result suggests that the metalinguistic training was effective, because a learning effect can probably be ruled out for assessments with a sentence repetition task. This finding also illustrates the importance of administering a retention measurement. The fact that no short-term effects were observed directly post-therapy does not exclude the possibility of finding effects after a longer time span. For now, it remains unclear why such an effect surfaces twelve weeks post-therapy. Sentence repetition tasks have proven their diagnostic value in identifying language disorders (Hesketh, Riches, & Vance, 2012; Seeff-Gabriel, Chiat, & Dodd, 2010). Perhaps sentence repetition tasks may prove to be valuable instruments in the evaluation of interventions. In our study, scoring was very tolerant, as the answer was scored as correct when children would realize a relative pronoun and a clause-final inflected verb in the relative clause. A more strict scoring system, taking other (grammatical or semantic) errors into account, such as the SASIT-E32 (Marinis, Chiat, Armon-Lotem, Piper, & Roy, 2011) might have been more revealing.

The results of the present study have some implications for theoretical frameworks of SLI. The finding that explicit teaching of grammatical rules to school-age children with SLI yields positive results appears to lend support to the Procedural Deficit Hypotheses (PDH) (Ullman & Pierpont, 2006). The PDH claims that children with SLI are impaired at grammatical rule learning because of a deficit in their procedural memory system. Instead, they rely on their declarative memory system to compensate for their procedural deficit. Apparently, children with SLI are able to learn grammatical rules when they are taught explicitly (in declarative memory) and learning is enhanced by visual (or multimodal) support. Furthermore, when we consider the present results in the light of grammatical competence versus performance, it is apparent that their grammatical competence is not deficient, as children with SLI are able to learn such complex grammatical syntactic constructions, although not as easy and early as typically developing children.

An important question is what exactly constitutes the active ingredient of the ‘MetaTaal’ programme. It is possible that the metalinguistic approach with multimodal support produced the observed progress, but it could also have been just the extensive exposure or practice with relative clauses (Sarilar, Matthews, & Kuntay, 2013). Furthermore, a point that is not often discussed in studies on metalinguistic intervention is that, although children with SLI appear to have poorer metalinguistic skills than typically developing children (Kamhi & Koenig, 1985; Menyuk, 1993), these skills can in fact be employed successfully to remediate grammatical problems in a metalinguistic approach. It is possible that the metalinguistic intervention also enhanced metalinguistic skills in children with SLI and has been a mediating factor in the children's language gains.

To conclude, the results of this intervention provide a preliminary indication that a relatively short metalinguistic training period of five weeks, with a total of five hours of treatment, can result in a significant improvement of relative clause production in school-age children with SLI. The medium to large effect sizes of the post-hoc comparisons between pre- and post-therapy and retention measurements hold a promise as regards the clinical relevance of this study. It is still unclear to what extent the effects of the intervention can be generalized to naturalistic situations. We have no direct evidence that the children started using more relative clauses in their spontaneous speech.

We feel that the 'MetaTaal' approach holds a promise for clinical practice. Apart from the positive effects it appears to have on children's verbal performance, the approach has a number of practical advantages. For one, the children thoroughly enjoyed working with the material. Some children wanted to use the bricks in the classroom and asked why they had not started using them much earlier on. Another advantage is that, although it is certainly possible to use written language together with the Lego® bricks, this is not necessary. Consequently, the children with SLI who are also poor readers can work with the material as well in the spoken modality.

Of course, several limitations apply to the present study. To begin with, the sample size in our study was rather small. A follow-up study with larger groups and a more rigorous design could be informative. Second, we tried to take working memory limitations into consideration by constructing two tasks that contained relatively short sentences (the OS Completion and 7-word Sentence repetition tasks). However, these tasks were too easy and caused some children to perform at ceiling already at the baseline measurements. Therefore, it might have been more revealing to use tasks containing items with an increasing sentence length. Third, in follow-up studies it would be advisable to assess the children with SLI beforehand with tasks measuring relative clause production and comprehension. Only the children performing poorly at such an assessment should consequently be included in the intervention study. Fourth, the present study showed that sentences with relative clauses are difficult to elicit, especially in the case of center-embedded versions. A follow-up study could therefore also incorporate a grammatical judgment task, which would tap into the children's grammatical knowledge of relative clauses. Together with production and comprehension tasks, this could provide a more comprehensive picture of the effectiveness of the intervention. Fifth, the collection and analysis of pre- and post-therapy language samples or classroom observations should certainly be included in the protocol of a future study, to see whether relative clause use also improves in therapy-external settings. Finally, the assessment of metalinguistic skills pre- and post-therapy could also be included in a future study in order to evaluate possible changes in metalinguistic skills as a possible mediator of language gains in an explicit metalinguistic intervention.

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Appendix A

Example of a MetaTaal therapy session (Session 6, duration 30 minutes)

Starting level: the child can produce and build right-branched sentences (OS-type relative clauses) in a structured (therapy) setting.

Targets for session 6:

- The child understands that center-embedded sentences (SS-type relative clauses) differ from previously build and produced OS-type relative clauses.
- The child can identify both SS-type and OS-type relative clauses and discriminate between the two relative clause types.

Activities:

1. Recapitulation of the previous session: this is what we did in the last session, and this is the sentence type that we built with the Lego bricks (optionally: build the last sentence on the base plate).
2. Introduce the target for today's session (today we'll start building sentences that have two bridges, and they are called double bridge sentences)
3. Put the crib sheet on the table that has both types of bridges (bridge and comma bridge)
4. Show the picture of two goats looking at a carrot (worksheet 1). Start with a SVO sentence: *The goat looks at the carrot.*

The goat looks at the carrot.

Build the sentence and ask: 'Do we know now which goat looks at the carrot? No, we don't, both of them look at the carrot'. 'Now we are going to add more information on one of the goats: *The goat that has spots, looks at the carrot*'.

Build the sentence together and introduce the comma bridge: 'When two red bricks (verbs) are next to each other, a comma bridge has to be placed between them. Between two verbs, you often make a pause when you speak, and you can write a comma'.

Then proceed to build the rest of the sentence: '*looks at the carrot*'.

5. Next, build an SVO, an OS type and an SS type sentence on the base plate. Examine the differences between sentences together. Point out the differences between the main clause and subordinate clauses.

Next, proceed with the second SVO sentence: *Marlies carries the flowers*

Then make a SS-type sentence: Marlies, who stands before the house, carries the flowers

Emphasize again that the relative clause (double bridge sentence) adds extra information!

6. Take worksheet 6.2 (three sentence types) and together with the child, arrange the different sentences according to the 3 sentence types on the base plate (short SVO, OS-type and SS-type).

Appendix B

Crib sheet for the LEGO bricks used with Metataal

<p>Green brick, 1x2</p>	<p>Determiner (the, a)</p> <p>(Dutch: <i>de, het, een</i>)</p>	<ul style="list-style-type: none"> Is it a small word? Is it 'de', 'het', or 'een'?
<p>Red brick, 2x3</p>	<p>Verb</p> <p>For instance: walk, read, talk</p> <p>(Dutch: <i>lopen, lezen, praten</i>)</p>	<ul style="list-style-type: none"> Is it something you can do?
<p>Yellow brick, 2x2</p>	<p>Preposition</p> <p>For instance: up, under, next to</p> <p>(Dutch: <i>op, onder, naast</i>)</p>	<ul style="list-style-type: none"> Can it be followed by 'the table'?
<p>Blue brick, 2x4</p>	<p>Noun</p> <p>For instance: tree, woman, dog, bag, coat</p> <p>(Dutch: <i>boom, vrouw, hond, tas, jas</i>)</p>	<ul style="list-style-type: none"> Can you place 'the' or 'a' before it? Is it a human, an animal or a thing?
<p>Brown brick, 2x2</p>	<p>Adjective</p> <p>For instance: green, beautiful, happy, small</p> <p>(Dutch: <i>groen, mooi, blij, klein</i>)</p>	<ul style="list-style-type: none"> Does it say something about the noun it precedes? Is het een kenmerk van de mens, het dier of het ding?
<p>Grey bridge with a white top</p>	<p>Complementizer</p> <p>For instance: who, that</p> <p>(Dutch: <i>die, dat</i>)</p>	<ul style="list-style-type: none"> Can it bridge two sentences together? Is it who or that ('die', 'dat')?

Appendix C

Figure C1.
Individual scores on the OS Completion task at each time point

Figure C2.

Individual scores on the SS Composition task at each time point

Figure C3.
Individual scores on the Recreation task at each time point

Figure C4.

Individual scores on the Repetition task (7 words) at each time point

Figure C5.
Individual scores on the Repetition task (12 words) at each time point

Figure C6.
Individual scores on the Comprehension task at each time point

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Figure 1.
Example of one test item from the relative clause comprehension task.

Figure 2.
Coordinated sentences built with Lego® bricks.

Figure 3.

Coordination with reduction sentence built with Lego® bricks.

Figure 4.
Sentence built with Lego® bricks containing a right-branching OS type relative clause.

De man die de hond aait , kijkt naar de vrouw
 The man that the dog strokes , looks at the woman
 (The man that strokes the dog, looks at the woman)

Figure 5.

Sentence built with Lego® bricks containing a center-embedded SS type relative clause.

Table 1

Means, Standard Deviations and Range of Age, and Quotient Scores of the Wechsler Non Verbal, PPVT-NL, and CELF-4-NL Subtests.

	Mean	SD	Range
Age (in months)	134.75	13.72	112-154
Wechsler Non Verbal-NL	99.64	10.31	85-116
Peabody Picture Vocabulary Test-NL	88.09	9.70	71-102
CELF Number Repetition Total	82.92	20.60	55-120
Formulated Sentences	83.73	7.99	75-95
Recalling Sentences	71.64	12.19	55-96
Word Definitions	77.75	11.78	55-90
Word classes	84.45	13.48	63-110
Understanding Spoken Paragraphs	91.82	8.15	80-105

Table 2

Means and Standard Deviations of the Raw Scores and Maximum Score (MaxSc) on the Relative Clause Tasks at the 5 Measurement Points (T1-T5).

RC tasks	MaxSc	Pre-therapy			Post-therapy	Retention
		T1 <i>M (SD)</i>	T2 <i>M (SD)</i>	T3 <i>M (SD)</i>	T4 <i>M (SD)</i>	T5 <i>M (SD)</i>
Relative clause production						
OS Completion	10	6.25 _a (2.05)	7.83 _a (2.17)	8.08 _a (1.51)	9.42 _a (0.90)	8.75 _a (1.14)
SS Composition	10	1.75 _a (3.25)	3.00 _a (3.86)	3.00 _a (4.00)	7.08 _b (4.23)	7.00 _b (4.20)
Recreation	16	6.50 _a (4.23)	8.00 _a (4.05)	9.25 _a (4.05)	11.42 _b (3.50)	12.33 _b (3.63)
Relative clause repetition						
Repetition 7 word	12	11.42 _a (1.17)	10.92 _a (1.31)	11.25 _a (1.22)	11.00 _a (1.13)	11.50 _a (0.80)
Repetition 12 word	15	9.25 _a (3.72)	9.58 _a (4.85)	9.75 _a (3.96)	10.75 _{ab} (3.30)	11.83 _b (3.46)
Relative clause comprehension						
Comprehension	28	19.25 _a (2.30)	18.25 _a (2.90)	21.17 _a (2.37)	20.17 _a (1.75)	21.67 _a (2.19)

Note. Mean scores in each row that share subscripts (a and b) do not differ significantly. All significant differences are $p < .01$.