The Efficacy of a Serious Game in the Grammatical Intervention of Children Aged 7-10 Years with a Developmental Language Disorder

Master thesis

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ABSTRACT

Background

Modern and digitized intervention approaches, such as serious games (SGs) could make an engaging and challenging contribution to keep children with Developmental Language Disorder (DLD) motivated during their often long-term intervention for grammatical difficulties. Recently, a SG has been developed for grammatical therapy for children aged 7-10 years with grammatical problems, based on an explicit approach. However, it is not yet known what the effect of this SG is on the grammatical development of children with DLD.

Aim

The objective of this study is to evaluate the efficacy of a serious game compared to conventional grammatical therapy to enhance grammatical complexity and accuracy of their spoken language in grammatical intervention with Dutch children with developmental language disorder aged 7-10 years.

Methods

In this single-case quasi-experimental AB-design language sample analysis was used to measure the change in mean length of utterances in words (MLUw), clausal density (CD) and grammatical accuracy (GA). Children aged 7;1-10;6 (YY;MM) with DLD (n=14) visiting a special school for children with speech and language disorders or a speech language therapy private practice in the Netherlands were included and received five weekly 20-minute sessions of conventional grammatical therapy (i.e. control condition, CC) followed by five weekly 20-minute SG sessions (i.e. experimental condition, EC).

Results

On a group level grammatical complexity and accuracy did not changed significantly after each condition, and after a total treatment period of 10 weeks. After the CC seven children had increased MLUw, three children had increased CD and seven children had increased GA. After the EC eight children had increased MLUw, six children increased CD and six children had increased GA.

Conclusion

It can be concluded that a serious game in grammatical intervention of Dutch children with DLD aged 7-10 years produced individual gains on grammatical complexity and accuracy of their spoken language compared to conventional grammatical intervention, but on a group level change was not significant.

Implications of key findings

Treatment using SGs offers children with DLD and SLTs additional or alternative options for grammatical therapy, to keep the children motivated in their often long-term intervention.

Keywords: developmental language disorder, grammar intervention, serious game, school-aged children, mean length of utterance

SAMENVATTING

Achtergrond

Moderne en gedigitaliseerde behandelvormen, zoals serious games (SG's) kunnen een boeiende en uitdagende bijdrage leveren om kinderen met een taalontwikkelingsstoornis (TOS) gemotiveerd te houden tijdens hun vaak langdurige grammaticabehandeling. Recent is een SG ontwikkeld voor kinderen van 7-10 jaar met grammaticale problemen, gebaseerd op een metalinguïstische aanpak met visuele ondersteuning. Het is echter nog niet bekend wat het effect van deze SG is op de grammaticale ontwikkeling van kinderen met TOS.

Doel

Het doel van dit onderzoek is evalueren of behandeling met een serious game voor zinsbouwtraining bij Nederlandse kinderen van 7-10 jaar met een taalontwikkelingsstoornis zal leiden tot verbetering van de zinsbouw in hun gesproken taal, vergeleken met de conventionele zinsbouwtraining.

Methode

Met een single-case quasi-experimenteel AB-design werd spontane taalanalyse gebruikt om de verandering in gemiddelde zinslengte in woorden (MLUw), proportie onderschikkende bijzinnen (CD) en grammaticale accuraatheid (GA) te meten. Kinderen van 7;1-10;6 jaar oud met TOS (n=14), die een speciale school bezoeken voor kinderen met spraak- en taalstoornissen of een eerstelijns logopediepraktijk in Nederland, werden geïncludeerd en kregen vijf wekelijkse sessies van 20 minuten conventionele grammaticale therapie (d.w.z. controleconditie, CC), gevolgd door vijf wekelijkse sessies van 20 minuten met de SG (d.w.z. experimentele conditie, EC).

Resultaten

Op groepsniveau was er na elke therapie conditie (CC en EC) en na de totale behandelperiode van 10 weken geen significante verandering van de grammaticale complexiteit en accuraatheid. Na de CC hadden zeven kinderen een verhoogde MLUw, drie kinderen een verhoogde CD en zeven kinderen een verhoogde GA. Na de EC hadden acht kinderen een verhoogde MLUw, zes kinderen een verhoogde CD en zes kinderen een verhoogde GA.

Conclusie

Geconcludeerd kan worden dat een serious game in zinsbouwtraining bij Nederlandse kinderen van 7-10 jaar met een TOS individuele voordelen oplevert op grammaticale complexiteit en nauwkeurigheid van hun gesproken taal vergeleken met conventionele zinsbouwtraining, maar op groepsniveau was de verandering niet significant.

Aanbevelingen

Behandelvormen met SG's biedt kinderen met TOS en logopedisten aanvullende of alternatieve opties voor zinsbouwtraining, om de kinderen gemotiveerd te houden in hun vaak langdurige therapie.

Trefwoorden: taalontwikkelingsstoornissen, grammaticale therapie, serious game, schoolkinderen, gemiddelde zinslengte

INTRODUCTION

Children with a developmental language disorder (DLD) may have difficulties with all aspects of language: articulation, auditory skills, vocabulary, grammar (morphosyntax) and pragmatics[1,2]. However, grammatical problems are a core problem of DLD[3]. Almost all children with DLD have difficulty acquiring grammatical rules[4,5].

The problems of children with DLD with the acquisition of grammar are usually persistent, which advocates language treatment in older children with DLD (over six years of age)[6–8]. However, few studies have been conducted on the effectiveness of grammatical treatment programmes for children with DLD older than six years[9,10]. Most studies focus on therapy programmes and techniques designed for children aged six years and younger, mostly based on an implicit learning mechanism[9,11]. In these mechanisms children learn the target structures through imitation, or a frequent and reinforced presentation by the therapist[9]. However, research has shown that older children with grammatical problems benefit greatly from an explicit approach of teaching the grammatical rules[9,12,13]. This metalinguistic approach aims to improve children's learning of the rules of grammar by creating conscious awareness of grammar, often in the context of specific visual cues[9].

Due to the scarcity of therapy programmes for older children, speech language therapists (SLTs) also use implicit programmes which they often adapt for older children with DLD[11]. Because children with DLD often undergo long-term treatment, it is important to keep the children motivated[14,15]. New forms of treatment, such as digital games, can contribute to this[16].

Digitization is growing in our society and emerging in education and health care[16,17]. One of the approaches in digital innovation are serious games (SGs)[18]. According to Haoran et al.[17] a SG is an interactive computer application, which is challenging and engaging, and supplies the user with competencies useful in reality. Protopsaltis et al.[18] state that SGs have strengths related to explicit learning as well as transferring implicit knowledge, skills and behaviours[18]. Although SGs are proven to be effective and motivating[16,17,19], to date, research had focussed mostly on students in secondary education and the games were not designed for speech language therapy. Washington et al.[20] showed that a computer-assisted programme, 'My Sentence Builder', is a viable, but not necessarily better treatment option for expressive grammar deficits in children with DLD. However, this programme was designed for preschool children and lacked the features of a SG.

Within a research project at HU University of Applied Sciences Utrecht, the Netherlands, aimed at innovation of language therapy for children with complex language problems, a SG has been developed by game designers, researchers and SLTs[21]. This game 'Bouke Bouwt' (in English: 'Bouke Builds') intended for grammatical therapy for children aged 7-10 years, is based on an explicit approach[22] and can be regarded as an adaptation of the treatment programme MetaTaal, an explicit multimodal and metalinguistic approach developed for children with DLD aged 10 years and older[11,22]. In this effective treatment program, children learn to build sentences with LEGO® blocks[11]. For the SG less complex sentence constructions

have been chosen, and more game elements were added to make the game suitable and attractive for the younger target group of children with DLD[22].
The usability of this SG has been studied within the project by the developers (project number RAAK MKB07.002). However, it is still unknown what the effect of this SG is on the grammatical development of children aged 7-10 years with DLD.
Therefore, the aim of the current pilot study is to evaluate the efficacy of a serious game compared to conventional grammatical therapy to enhance grammatical complexity and accuracy of their spoken language in grammatical intervention with Dutch children with DLD aged 7-10 years.

METHODS

Design

A single case experimental AB-design was used[23]. Five weekly 20-minute sessions of conventional grammatical intervention, the control condition, was followed by five weekly 20-minute sessions with the SG, the experimental condition (**Figure 1**).
As this is the first study to investigate the efficacy of this new treatment in children with DLD, this quasi-experimental study with pretest-posttest design can be regarded as an early efficacy study according to the five-phase model of Fey and Finestack[24].
Because the research period was limited and the efficacy of this new SG had not been researched before, a within-subjects design was chosen in this pilot study. An advantage of this within-subjects design is that it can provide initial objective data when time and resources are limited[25].
Each participant provided data in the baseline phase with the control condition (CC) and the intervention phase with the experimental condition (EC). Since the participants acted as their own control, it was possible to compare the differences in outcome between successive conditions with greater statistical power than in a between-subjects design with the same sample size[26]. Studies with a similar design had a sample size varying from 2-30 participants[9,10]. Because language sample analysis (LSA) is a time-consuming measurement method, the study period allowed a maximum of 15 participants.

Population and domain

Eligible children for this study were 7;0 to 10;11 years (YY:MM) and diagnosed with DLD[1], confirmed by a score at least -1 standard deviation of the mean on the Expressive Language Index (ELI) and Language Structure Index (LSI) or Language Memory Index (LMI, i.e. an index for language structure) of the Clinical Evaluation of Language Fundamentals in Dutch Fourth edition (CELF4-NL) or Fifth edition (CELF5-NL)[27,28], assessed within six months prior to the onset of this study.

Additionally, children were included if they received individual language therapy aimed at morphosyntax, had non-verbal cognitive abilities within normal limits and were able to produce sentences consisting of at least three constituents, observed by the treating SLT. Potential subjects who received speech, oral motor, voice or stutter therapy instead of language therapy or who received group therapy, were excluded from participation in this study.

Intervention

The CC (**Figure 1**) varied from working with speech language therapy programmes such as Transparant[29], a paper-based programme intended for younger children, and common speech-language stimulation techniques such as modelling and focused stimulation[9], combined with play with concrete toys, or pen and paper activities.
After five weeks of CC the EC with the SG (**Figure 1**) started. The SG 'Bouke Bouwt' teaches children the grammatical rules for morphosyntax in an explicit way, through play. The SG has a game objective and a learning objective. The game objective is to help aliens visiting Earth to learn our language. In return, the aliens help to clean up the polluted Earth. In the learning objective, the children learn to build sentences with coloured machines, which represent linguistic items (e.g. verb, noun, preposition). The sentences describe actions visible on scenes in the game (**Figure 2**). After the children see and hear the sentence with the corresponding scene they have to build the sentences. Feedback is given per word (i.e. machine), and a correct sentence gets a reward matching the game objective. In case of errors, the child receives an explanation and the sentence can be corrected or built again. The programme builds from simple four-phrase sentences (example 1) to six-phrase sentences, and from simple sentences to compound sentences (example 2).

(1) "het meisje ligt een uur in de sneeuw"
"the girl lies for an hour in the snow"
"*the girl lies in the snow for an hour*"

(2) "de jongen gooit munten in de fontein omdat hij een wens wil doen"
"the boy throws coins into the fountain because he a wish wants to make"
"*the boy throws coins into the fountain because he wants to make a wish*"

Procedures

Initially children in special schools for children with language impairments and additionally children treated in Dutch private SLT practices were recruited to reach the sample size. Besides receiving constructed comprehensive manuals and protocols for standardisation, the SLTs were informed about assessments and therapy programme through an online information session.

The spoken language of the children was audio/video-recorded by the SLTs and analysed for grammatical complexity and accuracy by the first researcher, since language sample analysis (LSA) is seen as the gold standard for analysis of grammatical development[30,31].
The assessment in all three measurement moments was carried out by the treating SLT and contained a personal narrative and a story telling task using the Multilingual Assessment Instrument for Narratives (MAIN). To avoid test-retest effect, at each measurement moment a different story was presented to the children (**Appendix-MAIN**)[32]. During the personal narrative the children were asked to explain their favourite game or sport and why, using prompts and open questions (e.g. "I am not too familiar with…" or "Can you explain more?")[33].
The first researcher transcribed each sample orthographically according to the Codes for Human Analysis of Transcripts (CHAT), a standardized transcription system[34]. This experienced SLT followed a training in CHAT. Points of doubt in the transcription and coding were discussed with the supervisor (RZ), an advanced expert in CHAT. The first 40 C-units of the sample were analysed, as this number is prescribed by TARSP[35–37]. A C-unit is defined as an independent clause with its modifiers[38]. This definition allows inclusion of incomplete utterances as analysable units, which often occur in spontaneous language of children with DLD. If the personal narrative did not evolve enough C-units, the story telling task was used to complete the number of 40.
Satisfaction with the SG was assessed at T2. Both SLT and child used a visual analogue smiley scale (VAS) with a star ranking (**Figure 3**).
During each condition the SLT kept a logbook (**Appendix-Logbooks**). During the CC the SLT made notes about the grammatical target, applied resources and the child's response. During the EC the SLT noted practiced structures and the response and experience of the child. The SLT selected sentences appropriate for the children's grammatical level, as well as the number of sentences to be practiced.
The first researcher visited the participating SLTs to collect the samples, the logbooks and the VAS. Questions were discussed by telephone, e-mail or during the visits.

Data collection

The primary outcome measure was mean length of utterances in words (MLUw), as targeted addition and expansion of sentence constituents and compound sentences should be reflected in utterance length in words[39].
The secondary outcome measures were clausal density (CD) and grammatical accuracy (GA). CD, a suitable measure of the grammatical development of older children, was calculated by dividing the total number of main and subordinated clauses by the number of C-units[40,41]. As an overall measure of GA, the percentage morphological and syntactic correct C-units was used[42].
Other study parameters were demographic data (age and gender), children's and SLTs satisfaction rating of the SG, and scores on standardized language tests. If the CELF4-NL was conducted, ELI and LSI were used, regardless of the age of the subject. If the CELF5-NL was

conducted, LSI was used for children up to 8;11 years of age and the LMI was used for children aged 9;0 years and older at the time of assessment.

Agreement

As a measure of consistency of the results the accuracy and completeness of transcription and coding was examined[43]. An external independent SLT (IG) transcribed 10% of the language samples (four transcripts), randomly selected from each of the three measurement moments. The first 40 C-units of the selected transcriptions were compared word by word. Point-to-point reliability at word level was 94% and 91% for utterance segmentation. Coding agreement for CD reached 82,5%, based on the number of identified subordinated clauses (10/12*100%). Coding agreement for GA reached 98,5%, based on the number of identified morphological and syntactic correct utterances (66/67*100%).

Data analysis

All analyses were performed using IBM SPSS Statistics version 28 (Armonk, NY: IBM Corp.). Due to the within-subjects design and small sample size, non-parametric tests were used. Primary and secondary outcome measures were analysed using Friedman's non-parametric analysis of variance (ANOVA), because Friedman's ANOVA detects differences across three or more measurements when the scores between those measurements are related to each other. When Friedman's tests were significant, post-hoc Wilcoxon signed-rank test was performed to examine significant differences between measurements T0-T1, T0-T2, T1-T2 in MLUw, CD and GA.
For each participant, level, trend and variability of the study parameters at the three measurement moments were visualized by a line diagram.
The other study parameters (participants characteristics and VAS) were analysed with descriptive statistics.

Ethical issues

This study was conducted according to the principles of the Declaration of Helsinki[44] and in accordance with the Medical Research Involving Human Subjects Act (WMO), the Good Clinical Practice (ICH-GCP) guidelines and the General Data Protection Regulation (in Dutch: AVG).
This study was reviewed and approved by the Dutch Ethics Committee of the HU University of Applied Sciences Utrecht, NL (178-000-2022, 16 February 2022).
Informed written consent was obtained from the parents of all participating children.

RESULTS

From 17 eligible children, a total of 14 Dutch children (eight boys) were included. Three children were excluded, because informed consent of their parents was not obtained (**Figure 4**). The participants characteristics can be found in **Table 1**.
Four children were treated in two Dutch private SLT practices (two SLTs) and 10 children in a special school for children with language impairments (eight SLTs). The participating children had a mean age of 8;8 years (YY;MM) (SD=15 months, range 7;1-10;6).
Four SLTs (four children) during the CC and three SLTs (five children) during the EC followed the protocols strictly, according to their logbooks. During the CC 10 children were treated weekly and during the EC eight children, besides an interrupting national holiday of one week for all children. Deviant treatment frequencies (i.e. twice a week, once in two weeks) in the CC (four children) and the EC (six children) were due to unexpected events.
Seven children during the CC and eight children during the EC received a treatment dose of 20 minutes each session (i.e. 100 minutes total intervention duration in each condition). For the other children dose varied (range 15-25 minutes per session) resulting in a varying intervention duration of the CC (range 89-105 minutes) and of the EC (range 105-118 minutes).
For all children the CC targeted syntax (three children simple sentences and 11 children compound sentences) and for four children morphology additionally. The SLTs used varied approaches (e.g. modelling) and resources (e.g. photo's, games). Four children received homework along with one or two sessions.
With the SG seven children practiced simple sentences. For five children the targeted syntactic structures varied from simple sentences to compound sentences and two children practiced only compound sentences. All children received explanation within the game or from the SLT. All SLTs used additional tools provided with the game (i.e. crib sheet and in magnets represented machines), according to the logbooks and oral elucidation to the first researcher during the visits. None of the children received homework during the EC. Five SLTs registered the number of practiced sentences per session (range 3-13).

MLUw

MLUw on group level was 5.45 at T0 (range 2.98-7.48), 5.27 at T1 (range 3.93-6.25), and 5.80 at T2 (range 4.58-7.95) (**Table 2**). Change between all three measurement moments was not significant (Friedman's ANOVA: $\chi^2(2)=.473$ and $p=.79$).
Visual inspection of the individual trajectories showed that after the CC in seven out of 14 children MLUw increased, in six children MLUw decreased and one child scored equal on MLUw (**Table 3**). The increase was found in the children aged 7-8 years, except for one child (9;9 years). The decrease was found in the children aged 9-10 years, except for one child (7;9 years).
After the EC eight out of 14 children had increased MLUw. Two of those eight children showed a steeper slope after the EC than after the CC and two children a slighter slope (**Figure 5)**. Six out of 14 children had decreased MLUw after the EC.

Four children had increased MLUw after each condition and two children had decreased MLUw after each condition.

Clausal Density

CD on group level was 1.08 at T0 (range 1.00-1.20), 1.07 at T1 (range 1.03-1.18), and 1.11 at T2 (range 1.00-1.18) (**Table 2**). Change between all measurement moments was not significant (Friedman's ANOVA: $\chi^2(2)=.894$ and $p=.64$).

The individual scores (**Table 3**) showed that after the CC three out of 14 children had increased CD, in seven a decrease was seen and four scored equal on CD. After the EC in six out of 14 children increased CD was seen, of which two showed a steeper slope after the EC than after the CC and two children had increased CD after their equalled CD after the CC (**Figure 6**). Four out of 14 children had equalled CD after the EC and four out of 14 children decreased on CD after the EC.

Two children had increased CD after each condition, three children had decreased CD and two children equalled CD aften each condition.

Grammatical Accuracy

On group level 33.9% utterances was correct at T0 (range 17.5-55.0), 34.4% at T1 (range 7.5-55.0), and 33.8% at T2 (range 10.0-50.0) (**Table 2**). Change between all measurement moments was not significant (Friedman's ANOVA $\chi^2(2)=.255$ and $p=.88$).

The individual scores (**Table 3**) showed that after the CC seven out of 14 children had increased GA and seven children had decreased GA. After the EC in six out of 14 children an increased GA was seen. These children were aged 9-10 years, except for one (7;1 years). Two of those six children had increased GA after each condition, but none of the children showed a steeper slope after the EC than after the CC (**Figure 7**).

One out of 14 children showed equal GA after the EC.

In seven out of 14 children a decreased GA was seen after the EC. Two children showed decreased GA after each condition.

Satisfaction with the SG

From all 14 children 11 scored the VAS with the highest score of five stars. Three children gave four stars. Two out of 10 SLTs scored the VAS with five stars and 8 with four stars.

DISCUSSION

The aim of this study was to evaluate the efficacy of a SG compared to conventional grammatical intervention in grammatical intervention with Dutch children with DLD aged 7-10 years. Grammatical complexity and accuracy did not changed significantly after each condition, and after a total treatment period of 10 weeks on a group level. These results suggest that use of a SG does not offer a therapeutic advantage over the use of conventional grammatical intervention for the treatment of grammatical deficits.

The lack of significance on group level is consistent with previous studies concerning computer-based grammatical intervention[20,45]. However a computer-based intervention lacks certain features a SG has.

As a first study of a new treatment, individual results are important as well. Four children showed increased MLUw and two children showed increased CD after each intervention condition. A possible reason for these low numbers could be found in the practiced targets, which varied from simple to compound sentences in both CC and EC. In contrast, significant change was found in studies targeting specific grammatical structures[11,46]. For example, in the study of Ebbels et al.[46] both used interventions (shape coding and semantic bootstrapping) made significantly greater gains in the overall use of verb argument structure than the control therapy (forming inferences with comprehending texts).

Targeting specific grammatical structures asks for a specific language measure[11,46]. However, due to the variety of targets in our study we used LSA to evaluate the child's language performance in a more naturalistic and ecologically valid way. As a consequence, some children could have lacked using practiced targets during those conversations.

No significant change was found in grammatical accuracy. This could be due to counting both morphological and syntactic errors, even though morphology was not targeted. The suggestion of Balthazar et al.[10] that learning of complex grammatical structures may be protracted could be another explanation. This implies that in intervention research a retention period should be included. However, due to a limited research period this could not be included.

The 10-week treatment period in this study resulted in a total intervention duration of 200 minutes. Although Zeng et al.[47] found no significant association between total intervention duration (mean duration 15 weeks, range three to 34 weeks) and effect size of intervention, a study of Smith-Lock et al.[48] confirms that expressive grammar treatment is most effective weekly over eight weeks rather than daily over 8 days. Compared to the study of Smith-Lock et al.[48] (total intervention duration of 480 minutes), our study (total intervention duration of 200 minutes), could have been too short to find significant treatment effect in expressive grammar. Besides, 60 minutes sessions are not feasible in Dutch daily SLT practice.

Although session frequency was protocolled, within-session dosage was not controlled. Therefore, the total number of exposure of the targeted grammatical structures was unknown. According to a recent systematic review of Frizelle et al.[49] dosage characteristics and their interactions in SLT are complex. With respect to morphosyntax interventions, they found that frequent, short sessions (2/3 times per week, approximately 2 minutes) and less frequent long sessions (once a week, approximately 20 minutes) have yielded the best outcomes in relation to composite language measures[49]. SGs could offer a solution for controlling for dose (within-session and frequency) by using a homework mode.

Finally, both SLTs and children were very satisfied with the SG. Research reveals that learning through SGs offers increased motivation and interest to learners through the role of "fun" learning[18], which is important if children undergo long-term treatment.

Strengths and limitations

A strength of this quasi-experimental study is the within subjects design. Since participants act as their own control it neutralizes different clinical therapy settings.

To strengthen experimental control and gain more confidence with respect to a pattern we could have used more measurement points in each condition. However, SLA is time consuming and due to limited duration of this graduation research (18 weeks) we had to choose for the minimal of three measurements.

Another limitation is total intervention duration. Each condition could be offered in five weekly 20-minute sessions. This is half of total intervention duration compared to other metalinguistic interventions (i.e. MetaTaal of Shape Coding), which have been proven effective[11,46].

Implications for clinical practice and future research

Based on the individual gains on grammatical complexity and high level of satisfaction with the game of both participants and SLTs the SG could be used as alternative or additional grammatical intervention with children aged 7-10 years with DLD, to keep the children motivated in their often long-term intervention.

A follow-up study with inclusion of control group, retention period, and a higher cumulative intervention dosage is recommended to measure the effect of a SG on grammatical development more specifically.

CONCLUSION

A serious game in grammatical intervention of Dutch children with DLD aged 7-10 years produced individual gains on grammatical complexity and accuracy of their spoken language compared to conventional grammatical intervention, but on a group level change was not significant. Treatment using SGs offers children with DLD and SLTs additional or alternative options for grammatical therapy.

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TABLES and FIGURES

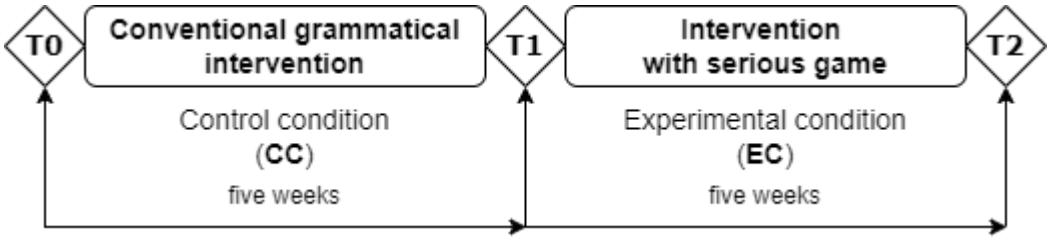


Figure 1 *Flow Chart of the Study Design*

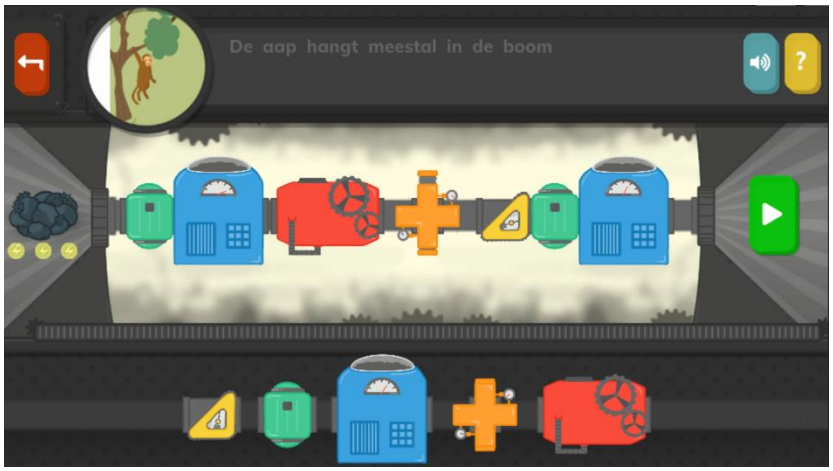


Figure 2 *Screenshot of a Sentence build in the SG 'Bouke Bouwt'*

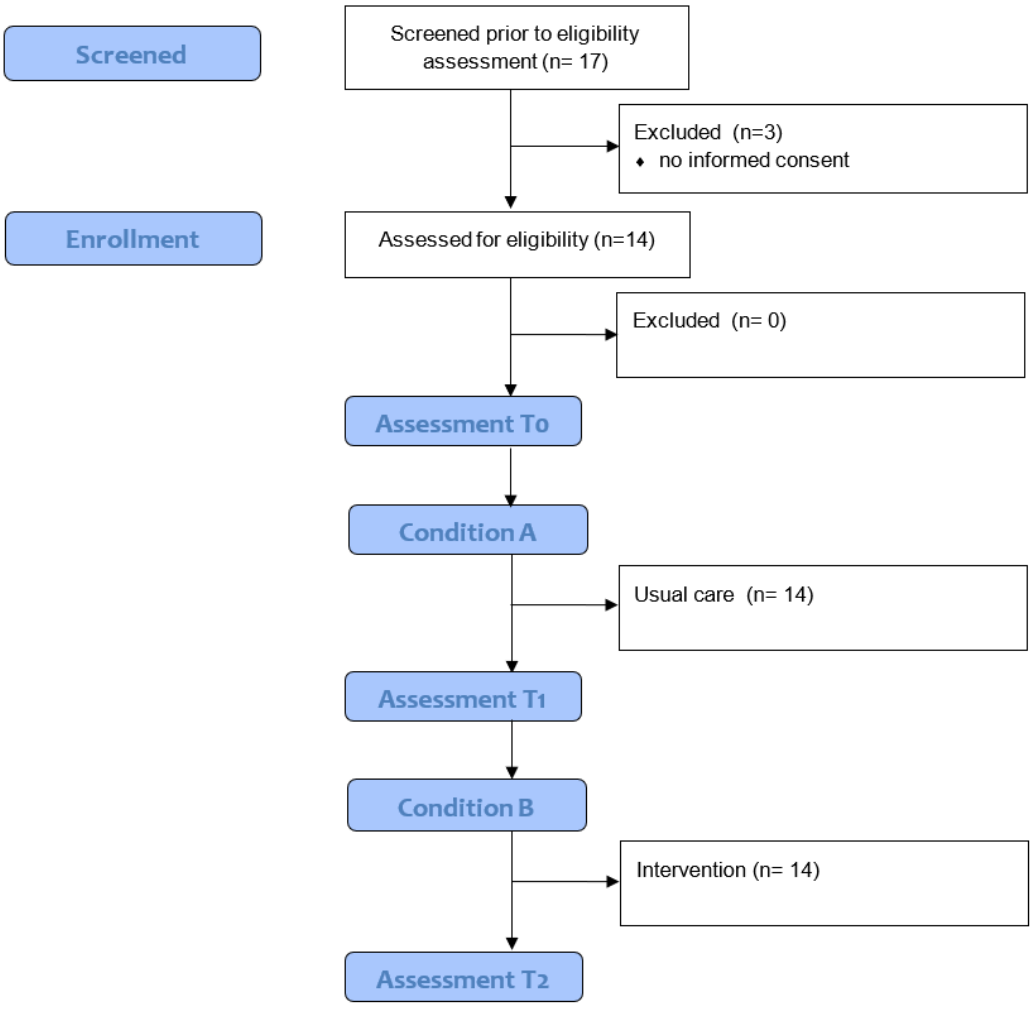
Figure 3 *Visual Analogue Smiley Scale for assessing Satisfaction with the SG*

Table 1

Characteristics of the Participants

Characteristic	Mean	Standard deviation	Range
Age (YY;MM)	8;8	1;3	7;1 - 10;6
CELF4/5-NL[1] ELI[2] (Q-score[5])	60.57	8.36	47 - 76
CELF4/5-NL[1] LSI[3]/LMI[4] (Q-score[5])	63.71	10.75	49 - 87

[1]Clinical Evaluation of Language Fundamentals in Dutch fourth edition (CELF4-NL), [2]Expressive Language Index (ELI), [3]Language Structure Index (LSI), [4]Language Memory Index (LMI, i.e. an index for language structure of CELF5-NL). [5]Q-scores between 86 and 114 are considered average. Q-scores between 78 and 85 suggests a mild impairment, between 70 and 77 a moderate impairment and of 70 and below an severe impairment.



Citation: Eldridge SM, Chan CL, Campbell MJ, Bond CM, Hopewell S, Thabane L, et al. CONSORT 2010 statement: extension to randomised pilot and feasibility trials. BMJ. 2016;355.

Figure 4 *Flow Diagram of the Participants*

Table 2

Group Scores of Mean Length of Utterances in words (MLUw), Clausal Density (CD) and Grammatical Accuracy (GA) from the Language Sample Analysis

	Control condition[1]		Experimental condition[2]			
	T0		T1		T2	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
MLUw[3]	5.45 (1,00)	2.98-7.48	5.27 (0.75)	3.93-6.25	5.80 (1.00)	4.58-7.95
CD[4] (ratio)	1.08 (0.06)	1.00-1.20	1.07 (0.04)	1.03-1.18	1.11 (0.95)	1.00-1.18
GA[5] (%)	33.9 (9.7)	17.5-55.0	34.4 (12.9)	7.5-55.0	33.8 (11.6)	10.0-50.0

Notes: [1]Control condition is conventional grammatical intervention, [2]Experimental condition is intervention with the SG, [3]MLUw is calculated by dividing the total number of words in the first 40 C-units by the 40 C-units, [4]Clausal density (CD) is a ratio calculated by dividing the total number of main and subordinated clauses by the number of subordinated clauses, [5]Grammatical accuracy (GA) is the percentage grammatical correct C-units of the first 40 C-units.
The mean scores in each row do not differ significantly. All significant differences are $p < .05$.

Table 3

Individual changes of Mean Length of Utterances in words, Clausal Density and Grammatical Accuracy after control condition and experimental condition

Subject		MLUw[1]		CD[2]		GA[3]	
	Age T0 (YY;MM)	T0-T1 CC[4]	T1-T2 EC[5]	T0-T1 CC[4]	T1-T2 EC[5]	T0-T1 CC[4]	T1-T2 EC[5]
1	10;0	-	+	-	-	-	+
2	7;1	+	+	=	=	+	+
3	7;6	+	-	-	-	+	-
4	9;2	-	-	-	=	+	+
5	10;6	-	-	-	-	+	-
6	7;10	+	+	=	+	+	-
7	7;11	=	-	-	+	-	=
8	9;9	-	+	=	+	-	+
9	9;9	+	-	-	=	-	+
10	7;9	-	+	-	+	+	-
11	7;7	+	+	+	-	-	-
12	7;3	+	-	=	=	+	-
13	10;2	-	+	+	+	-	+
14	8;8	+	+	+	+	-	-

Notes: [1]Mean Length of Utterances in words, [2]Clausal Density, [3]Grammatical Accuracy, [4]Control Condition, [5]Experimental Condition. + means increased result, - means decreased results and = means equal result after the intervention condition (CC of EC).

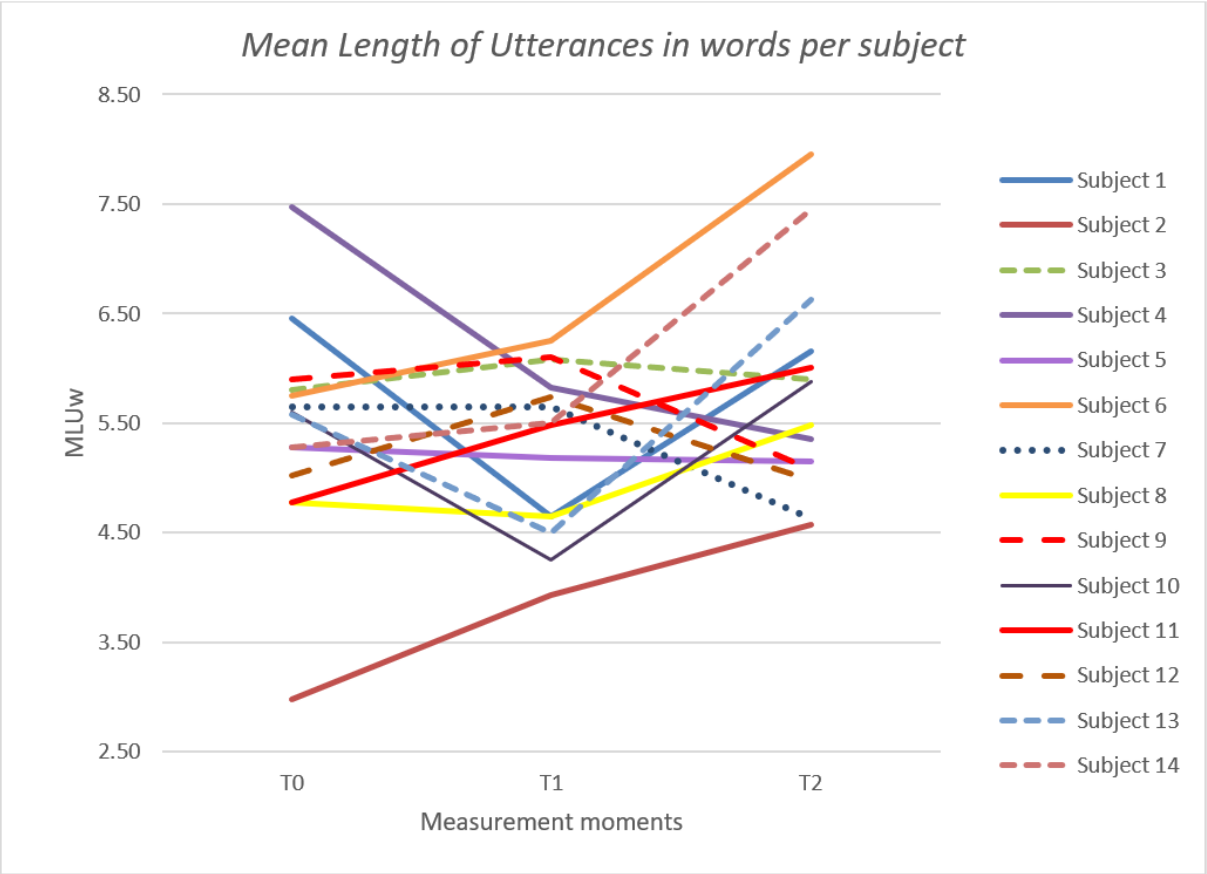


Figure 5 *Mean Length of Utterances in words per Subject*

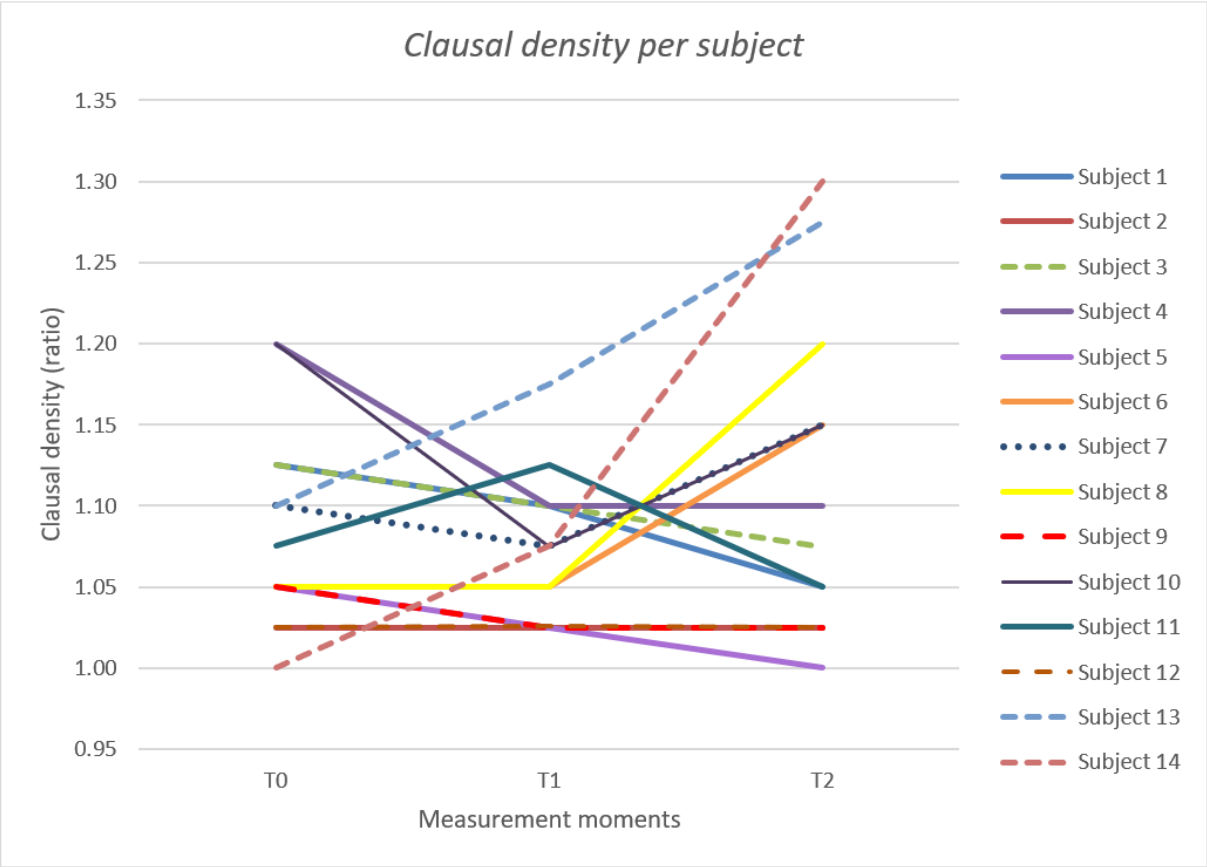


Figure 6 *Clausal Density per Subject*

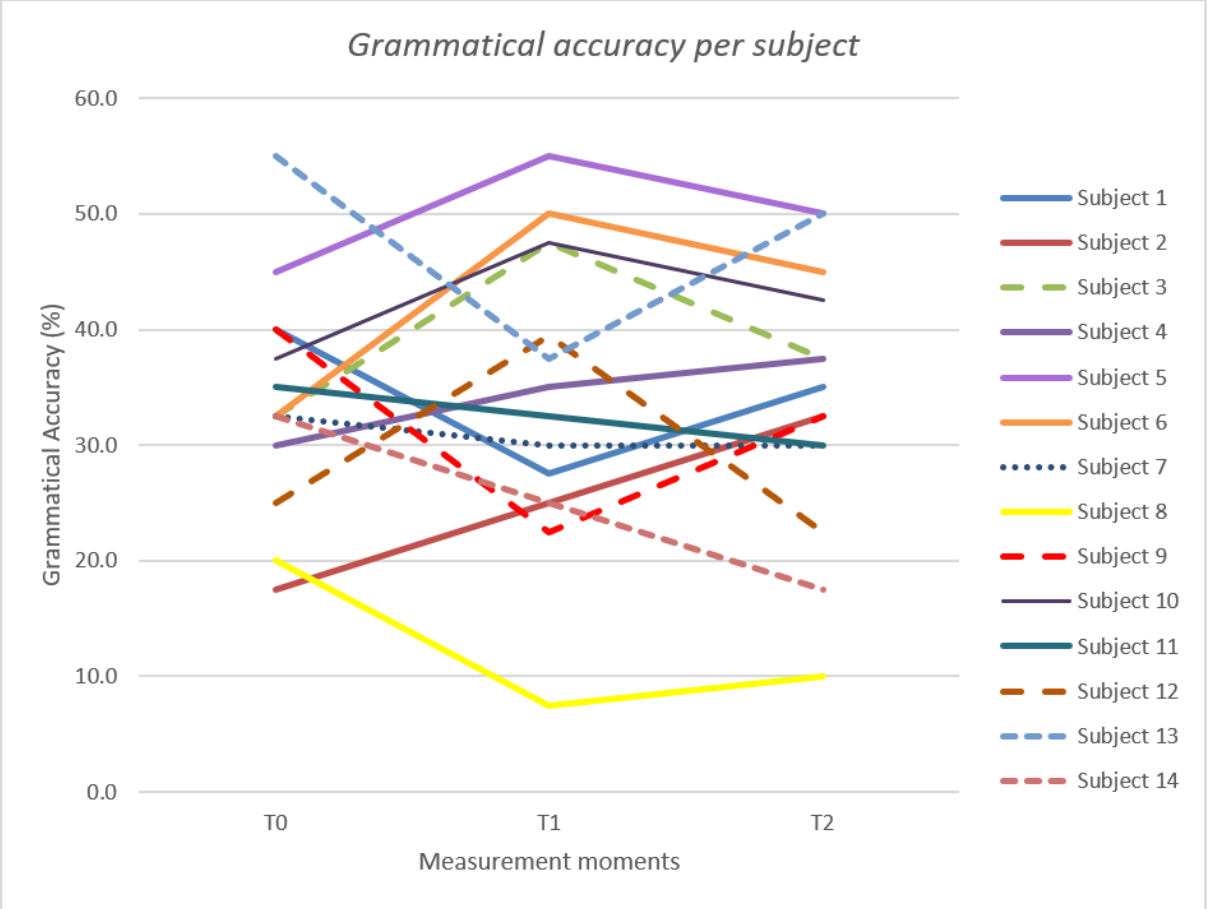


Figure 7 *Grammatical Accuracy per Subject*

HOGESCHOOL UTRECHT

Logboek Gebruikelijke Therapie

Kind Code: Subject_

Vul de kind code in.

In dit logboek voor de therapieperiode met de gebruikelijke therapie beschrijf je kort per sessie onderstaande aspecten. Vermeld de datum per sessie.
Noteer de grammaticale doelen, waar je aan hebt gewerkt en welke programma's/middelen/materiaal je hiervoor hebt gebruikt. Schrijf erachter in de betreffende kolom hoe lang er is geoefend (tijd) per doel, en hoe het ging (evaluatie). Vermeld hierbij niet de naam van het kind. Hiervoor in de plaats kun je de kind code gebruiken.
Bij de evaluatie kun je bijvoorbeeld denken aan of het kind het (snel) begreep en oppakte, of het kind meedeed en of het kind enthousiast was.

Sessie 1 – datum:

Grammaticaal doel	Gebruikt programma/middel/materiaal	Tijd (min)	Evaluatie

Sessie 2 – datum:

Grammaticaal doel	Gebruikt programma/middel/materiaal	Tijd (min)	Evaluatie

Sessie 3 – datum:

Grammaticaal doel	Gebruikt programma/middel/materiaal	Tijd (min)	Evaluatie

Sessie 4 – datum:

Grammaticaal doel	Gebruikt programma/middel/materiaal	Tijd (min)	Evaluatie

Sessie 5 – datum:

Grammaticaal doel	Gebruikt programma/middel/materiaal	Tijd (min)	Evaluatie

APPENDIX -*Logbooks Experimental condition Intervention with the serious game*

HOGESCHOOL UTRECHT

Logboek Therapie met de Game

Kind Code: Subject_

Vul de kind code in.

In dit logboek voor de therapieperiode met de game beschrijf je kort per sessie onderstaande aspecten. Vermeld de datum per sessie.
Noteer de geoefende zinsconstructie(s). Schrijf erachter in de betreffende kolom hoe lang er is geoefend (tijd) per zinsconstructie, en hoe het ging (evaluatie). Vermeld hierbij niet de naam van het kind. Hiervoor in de plaats kun je de kind code gebruiken.
Bij de evaluatie kun je bijvoorbeeld denken aan of het kind het (snel) begreep en oppakte, of het kind meedeed en of het kind enthousiast was.

Sessie 1 – datum:

Geoefende zinsconstructie	Tijd (min)	Evaluatie

Sessie 2 – datum:

Geoefende zinsconstructie	Tijd (min)	Evaluatie

Sessie 3 – datum:

Geoefende zinsconstructie	Tijd (min)	Evaluatie

Sessie 4 – datum:

Geoefende zinsconstructie	Tijd (min)	Evaluatie

Sessie 5 – datum:

Geoefende zinsconstructie	Tijd (min)	Evaluatie

APPENDIX -MAIN stories