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Master's Thesis

Written language performance in adults with moderate to severe congenital hearing impairment

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Contents

Abstract

Aim: The aim of this study was to examine whether the written language performance of adults with moderate to severe congenital hearing impairment (MSCHI) differs from that of normal-hearing adults (NH) at group level and whether the written language performance of MSCHI subjects differs from their spoken language performance at group level. **Method:** Written language performance was examined by analysing written samples in expository discourse genre. The written output of the 20 MSCHI adults and 9 NH adults was analysed using the STAP method (Dungen & Verbeek, 1999), containing parameters on syntactic complexity, morphosyntax, semantics, pragmatics, spelling, and punctuation. **Results:** At group level, the written language performance of the NH and MSCHI group only differed significantly on two variables: 'mean length of the 5 longest utterances in words' (MLUL) and 'semantically deviant utterances'. When comparing the parameter values of the spoken samples and the written samples at group level, the MSCHI group scored significantly better in the written samples on 'mean length of utterances' (MLU), several other measures of syntactic complexity, morphosyntax and 'implicit use of anaphora'. **Conclusion:** Our data show that both the MSCHI and NH group show similar written language performance at group level for most parameters. However, in comparison between the written and spoken language performance of the MSCHI group a difference at group level was found for morphosyntactic variables. Less morphosyntactic errors occurred in the written samples, caused by a benefit for the MSCHI group due to the modality specific characteristics of writing. Thus, the difference in written language performance compared to spoken language performance of the MSCHI group at group level seems not to be caused by poorer language competence but by the difference in output processing. As written language performance may influence spoken language performance, education and therapy for children with hearing impairment should have a greater focus on written language.

1. Introduction

Hearing is of great importance to speech and language development. One of the most difficult tasks in child development is to master written and spoken language (Briscoe et al., 2001). Congenitally impaired hearing presents an educational handicap on mastering written and spoken language (Luckner & Isaacson, 1990). Many learners who are deaf or hearing-impaired have difficulty gaining access to the education being offered, because of incomplete auditory signals and challenges related to the development of language (Reed, 2003). In their study on language development in adolescents with congenital mild to moderate hearing loss, Delage and Tuller (2007) note that hearing loss entails distortion of sounds, resulting in partial and degraded input of language. This causes an atypical language development, which may have long-lasting effects (Robier, 2001 In: Delage and Tuller, 2007). Thus, congenital hearing impairment imposes an obstacle to the spoken and written language development and linguistic skills of individuals with hearing-impairment.

The development of written language depends on another form of expression such as spoken language or sign language (McAnnally et al. In: Luckner & Isaacson, 1990). It is a complex and difficult task to master, for both hearing and hearing-impaired students (Antia et al., 2005). If sounds are not clearly received, this can cause difficulties in the development of written language (Yalçinkaya et al., 2009). Several authors investigated the writing of congenitally hearing-impaired students. It is important to note (in accordance with the findings of Antia et al, 2005) that most authors have studied the skills of students with severe to profound hearing loss, i.e. a hearing loss of more than 70 dB. Little is known about the written language performance of adults with moderate to severe hearing impairment, i.e. a hearing loss of 35 to 95 dB. Therefore, the studies mentioned below give an outline of the possible effects of severe to profound hearing loss, but these effects will not apply equally in case of moderate to severe hearing impairment.

Research on the written language output of students with severe to profound hearing impairment reveals that these students show poor performance

in mastering the process of producing written texts (Luckner & Isaacson, 1990). Yalçinkaya et al. (2009) state that an individual's ability to perceive sounds may influence his chance to succeed in translating sounds of a language into writing. This indicates that both the deficit in auditory perception and the developmental delay on the primary language system have an adverse effect on written language development of individuals with hearing-impairment (Luckner & Isaacson, 1990). Observing the obstacle imposed by congenital hearing impairment to language development and linguistic skills more closely, hearing impairment causes a restriction on the development of the ability to read and write. Thus, written language output is influenced by both language development and the development of reading and writing skills.

Regarding the content of written text, hearing-impaired writers show good written language performance at word and sentence level, but have difficulty creating text that demonstrates coherent relationships (Black, 1982, In: Luckner & Isaacson, 1990). Some research has been done on the syntactic complexity of the written output of hearing-impaired individuals, as well as on their morphosyntactic skills. In their research investigating deaf college students' written English, Channon and Sayers (2007) compared essays of these students to essays created by several editors. The deaf college students demonstrated low mastery of independent clause markers, demonstratives, third-person singular neuter pronouns, and modals related to possibility. The deaf college students however did have relatively high mastery of the first-person singular and punctuation. These students overused some dependent clause markers, the second- and third-person neuter pronouns, quantifiers, the verb *do* and the modals *could* and *will*. They were also inclined to produce sequences of two or more main clauses, avoiding commas and periods in particular, rather than fragments. It is important to note that Channon and Sayers do not yet know whether this pattern could also be found in hearing students learning English as a second language, or less skilled native users (such as young children).

Research comparing the written language performance of normal-hearing students and students with profound hearing impairment indicates that hearing-impaired students create sentences of shorter length than those of normal-

hearing students (Ivimey & Lachterman, 1980, In: Luckner & Isaacson, 1990). Research reported by Gormley and Sarachan-Deily (1987, In: Luckner & Isaacson, 1990) suggests that hearing-impaired students make more errors in spelling, punctuation and grammar compared to students with normal hearing.

Written language and spoken language differ in several aspects. Regarding general differences between spoken and written language, syntactic complexity is found to be greater in written language than in spoken language. Written language contains more subordinate and adverbial clauses, longer and more complex utterances and higher values for mean length of utterance (among others: O'Donnell, 1974). In their study, Ravid and Zilberbuch (2003) compare morphosyntactic constructions in the development of spoken and written Hebrew. The authors note that spoken texts require shared knowledge and cooperation between different speakers, because of limitations caused by the pressure of online processing. Furthermore, spoken texts contain a large amount of unnecessary material and the pressure of online processing does not permit much organization and planning. Spoken texts are also less lexical and informative than written texts. Because of the absence of pressure of online processing written texts allow deliberation and revision. These differences illustrate the modality specific characteristics, i.e. the different characteristics of both spoken and written language. Chafe et al. (1987) investigated these modality specific characteristics as well. Writing allows the writer to deliberate and revise the choices he makes whereas speakers need to make such choices very quickly. This results in a more varied vocabulary in written language compared to spoken language. Utterances are found to be longer in written language than in spoken language. Spoken utterances are influenced by limitations of the short-term memory and the speaker's ability to concentrate. These factors do not play a role when writing utterances, leading to sentences of strikingly longer length in written samples. Writers are freed from constraints caused by limitations related to what can be focused on at one time. Furthermore, writers are not bordered by short-term memory limitations.

Previous studies have investigated the relationships between writing skills and spoken language skills, and whether proficiency in writing is related to spoken language proficiency. Most of these studies compare the written and spoken language of atypical learners, such as learning-disabled individuals (MacArthur et al., 2008). As previously mentioned, spoken language is the foundation on which written language performance is built. According to MacArthur et al. (2008) spoken and written language are closely related. Children with well-developed spoken language would theoretically develop writing more efficiently and should show a faster progress because these children would likely rely on their spoken language knowledge while writing (MacArthur et al., 2008). The authors also state that written language may influence spoken language. Writing can make certain aspects of language more noticeable to the learner.

Unfortunately, most research investigating differences between spoken and written language performance focus on individuals with normal hearing. Little literature is available on the differences between spoken and written language performance in hearing-impaired individuals.

A recent comparative study on spoken language performance of normal-hearing adults and adults with congenital moderate to severe hearing impairment (Huysmans et al., to appear) examines long-term effects of moderate to severe congenital hearing impairment (MSCHI) at an age when maturation of language performance is complete, i.e. in adults. Spoken language performance in Dutch in 10 normal-hearing (NH) adults and 20 adults with MSCHI was studied, using analysis of spontaneous language (STAP) and a standardised test (CELF-4NL). Spontaneous language was analysed with regard to morphosyntax, syntactic complexity, semantics, pragmatics, (dis)fluency, and intelligibility. Data showed significant differences in the area of morphosyntax: congenitally hearing-impaired adults produced more ungrammatical utterances and their error patterns differed from the normal-hearing group. The MSCHI group produced significantly more errors than the NH group regarding the morphosyntactic categories 'number of ungrammatical utterances', 'morphosyntactic errors',

'incorrect determiner', 'missing determiner', 'subject-verb agreement error' and 'adverb error'.

The present study is an explorative study, as a part of the broader study by Huysmans et al. (to appear). Although the present study also examines the language performance in the same participants, it focuses on written language performance instead of spoken language performance. The present study analyses the written samples of the same groups of participants as the study on spoken language performance (Huysmans et al., to appear). Its aim is to answer the question whether at group level differences can be found between the written samples of the MSCHI group and the NH group. Additionally the present study evaluates whether these differences between both groups in written language performance are similar to the differences in spoken language performance found at group level between the MSCHI and NH group. Furthermore it aims to answer the question whether the written language performance of the MSCHI adults differs from their spoken language performance. Can written tests be used to survey the differences in linguistic skills between congenital hearing-impaired and normal-hearing individuals? In order to come to an answer, the first step of this project was to compare the writing of hearing-impaired participants with the writing of participants with normal hearing. The second step was to compare these results to the results of the recent study on spoken language performance (Huysmans et al., to appear). By making this comparison the project aims to answer the question whether the outcomes of speech performance in normal-hearing individuals and hearing-impaired individuals are also reflected in their writing.

The present study evaluates whether the analysis of written samples can be used to survey the differences in linguistic skills between congenital hearing-impaired and normal-hearing individuals. If the results of this project show that written samples indeed can be used for this purpose, written test may be used in different settings. In the near future written tests might be used as a tool for further research to demonstrate differences between hearing-impaired and normal-hearing groups of participants. This method would reduce the time

needed for data analysis. Written tests might also have a clinical use if written tests turn out to be useful to determine the linguistic skills of an individual. This specific information could contribute to realistic expectations regarding the effect of the use of a Cochlear Implant (CI).

In conclusion, the present study aims to answer the following questions: Does the written language performance of adults with moderate to severe congenital hearing impairment (MSCHI) differ from the written language performance of adults with normal hearing (NH) at group level? Furthermore, does the written language performance of the same MSCHI individuals differ from their spoken language performance at group level, as studied by Huysmans et al.(to appear)? Regarding the expected outcomes of this study it is important to note that previous research on the spoken and written language performance of adults with hearing impairment mainly studied individuals with profound hearing impairment. As the present study evaluates the performance of adults with moderate to severe hearing impairment, hypothesis drawn from previous research should be regarded to be the utmost possible outcomes. Because of a difference in study population the results of the present study might be less extreme than the outcomes on the performance of individuals with profound hearing impairment.

Considering what is known about the spoken and written language performance of adults with severe to profound hearing impairment, this study hypothesises that the MSCHI adults may show poorer written language performance regarding length of utterances, syntactic complexity, spelling, punctuation, and morphosyntactic errors than NH adults. Hearing loss can cause a delay on the development of spoken language which can pose an obstacle to the development of written language. When comparing the spoken language performance to the written language performance of the MSCHI adults, results are expected to show benefit from modality specific characteristics. Written texts can be revised and can be produced without the pressure of online processing of spoken language. Therefore the MSCHI adults are expected to show a better performance in written than in spoken language.

2. Method

2.1 Participants

Two groups of participants were needed for this study: one group of adults with moderate to severe congenital impairment and one group of individuals with normal hearing. Eligible participants for this research were approached in various ways. Firstly a research study advertisement was posted at the ENT department of the VU Medical Centre in Amsterdam. Secondly, patients of the diagnostic audiological centre who met the inclusion criteria received an invitation to participate in the study. There were several selection criteria for participation in this research. Individuals should have Dutch as their mother tongue, be aged between 20 and 45 years old and have an education level of VMBO[1] or higher. Participants were not diagnosed with cognitive impairment, nor specific language impairment or a psychiatric disorder.

Moderate to severe congenital hearing-impaired group (n_{mschi}=20)

Twenty adults with moderate to severe congenital hearing impairment participated in this group. All hearing-impaired participants had a moderate to severe congenital hearing impairment (PTA between 35 and 95 dB HL since birth). The age of the participants ranged from 20 to 45 years (mean age 28 years). All participants underwent pure tone audiometry. The participants' current PTA (PTA = pure tone average, i.e. mean of the thresholds at 500, 1000, and 2000 Hz) of the best ear ranged from 35 to 108 dB HL. Medical history or previous PTA of the MSCHI group showed a hearing impairment at birth between 35 and 95 dB HL. All but one received hearing aids at an early age, i.e. before the age of 5 years. One hearing-impaired participant did not use hearing aids till the age of 18 because of a steep slope in his audiogram. In eight MSCHI participants, the hearing loss progressed over time. Four of them are using a cochlear implant at the current age.

All congenital hearing-impaired participants reported not to have been in contact with users of a sign language during their school years. At primary school

[1] Dutch 'preparatory middle-level applied education', similar to UK GCSE's At C level / US 10th Grade

age, 11 out of 20 of the congenital hearing-impaired participants attended regular schools, while 9 attended a school for the hearing-impaired. At secondary school age, two participants who attended a primary school for the hearing-impaired switched to a regular secondary school. Regarding the current level of education of the participants, it should be noted that the participants with MSCHI on average had a higher level of education than the NH participants.

Normal-hearing group (n_{nh} =9)

Nine individuals with normal hearing were participants in this group. They were selected mainly with help from the employees of the ENT department of the Vrije Universiteit Medical Centre (employees themselves, or acquaintances of employees). Their age ranged from 20 to 34 years (mean age 25 years). Also the participants of this group underwent pure tone audiometry. The participants' best ear pure tone average did not exceed 18 dB HL.

Unfortunately one participant from the normal-hearing group who participated in the study on spoken language performance failed to participate in the present study on written language performance. Therefore this study contains 9 written samples, whereas the study on spoken language performance contains 10 spoken samples.

2.2 Procedure

The participants were asked to sit down behind a computer in a soundless room. On the screen they found a Microsoft Word file, containing two questions written in Dutch (see image 1 for the English translation). The participants were asked to answer these questions in approximately 200 words per question. They were told that the whole task should take about 20 minutes, with a maximum of 30 minutes. The participants were free to choose which question they wanted to answer first. They had access to the Microsoft Word spelling checker.

Writing test questions:

1. You get the chance to go on a holiday and you get to pick two people to join you. Which people would be the best persons for you to accompany you? Explain why you would pick them.
   Imagine that your passport and money would be stolen, what do you think the others would do?
2. In January 2010 a heavy earthquake occurred in Haiti. Approximately 200.000 people died and a lot of buildings and roads were destroyed. In February there was a travel agency that offered tours to the disaster area, so that tourist could see for themselves how people in Haiti were working on the rebuilding. What do you think of this? Do you think it's right or wrong that these tours were being offered? Give arguments.

Image 1: The two questions of the writing test translated from Dutch to English.

These questions were created by the researcher based on a set of tasks to assess the writing skills of students in the discourse genre of expository discourse[2]. The expository discourse genre was considered most suitable for the writing test, because this genre is known to lead to syntactically more complex use of language. A task to elicit language in expository discourse is considered to be a difficult cognitive challenge (Berman & Verhoeven, 2002).

2.3 Data and analysis

The data set of the study on spontaneous speech samples (Huysmans et al., to appear) was used as a starting point for the data set for analysis of the written samples. All written answers were segmented into t-units, or utterances, using the definition from the STAP-method (Dutch abbreviation for Spontaneous Language Analysis Procedure[3], van den Dungen & Verbeek, 1999). Van den Dungen and Verbeek extended the original definition by Hunt (1965) with respect to conjunction reduction. The STAP-definition for a t-unit, which is used in the current research, is: "A basic utterance is a simple main clause with the

[2]Website for English language writing tips and tricks, information about writing styles and genres: http://www.thewritingsite.org/resources/genre/expository.asp accessed January 13th, 2011

[3] Website of the University of Amsterdam Linguistics department on the STAP method with information on how to obtain an STAP guidebook: http://www.student.uva.nl/ATW/object.cfm/29D0CDF4-1321-B0BE-68B5053AD6E7B11C/3D5415B8-1321-B0BE-A46FF466FCD6C86A accessed January 13th, 2011

attached subordinate clauses. Coordinating main clauses are divided into separate utterances, unless there is conjunction reduction".

All written language samples were analyzed based on variables from the following linguistic domains:

1. Syntactic complexity
2. Morphosyntactic correctness
3. Semantics
4. Pragmatics
5. Modality specific items: spelling and punctuation errors

For the linguistic domain of syntactic complexity 'mean length of utterance in words' (MLU) and 'mean length of the 5 longest utterances in words' (MLUL) were calculated. Additionally values for twelve other measures of syntactic complexity were enumerated, such as 'use of nouns', and 'use of subordinate clauses'. Appendix A shows an overview of the variables of the linguistic domain of syntactic complexity.

Regarding the linguistic domain of morphosyntactic correctness the number of ungrammatical utterances and morphosyntactic errors were counted. For the qualitative analysis of morphosyntactic errors written samples were analyzed focusing on several morphosyntactic error categories. Appendix A gives an overview of all variables used for the linguistic domain of morphosyntactic correctness.

Analysis of the linguistic domain of semantics was performed based on the variable 'semantically deviant utterances'. Pragmatics were analyzed through the variables 'pragmatically deviant utterances' and 'implicit use of anaphora'. Appendix A also shows the variables for semantics and pragmatics.

Variables regarding intelligibility and (dis)fluency were eliminated, as these are inherent to speech and have no counterpart in writing. As a replacement, the category 'modality specific items' was added (Gregg et al., 1991). This category contains punctuation errors, spelling errors and errors in the use of capitals. The classification of items being errors was based on rules from a Dutch

grammar book (Grammatica Nederlands; Houët, 1988) and websites on Dutch rules on punctuation, spelling and the use of capitals[4]. Note that these modality specific items do not correspond to the variables regarding intelligibility and (dis)fluency in speech. In fact, none of the modality specific items for writing have direct equivalents in spoken language (Stubbs, 1980).

Due to the nature of the written test, which only demanded the participants to answer in approximately 200 words, sample sizes differed between participants. Therefore, absolute values were rescaled to relative values to ensure comparability of the samples. The non parametric Mann-Whitney U-test was used to compare data between groups at group level for all variables.

3. Results

3.1 Sample size

Each participant answered two questions that were known to lead to syntactically more complex use of language, as discussed in section 2.2. This task resulted in samples with a variable total of utterances. For the NH group, sample size ranged from 13 to 34 utterances, with a median of 28 utterances. For the MSCHI group, sample size ranged from 15 to 38 utterances, with a median of 28.5 utterances. The sample size of both NH and MSCHI did not differ significantly [Mann-Whitney $U = 71.000$, $n1 = 9$, $n2 = 20$; $p > 0.05$]. Thus the groups did not differ in the amount of written language that was available for analysis.

3.2 Results of writing performance of the MSCHI and NH group

This section will discuss the data necessary to answer the first question of the current study, as mentioned in section 1: Does the written language performance of adults with moderate to severe congenital hearing impairment (MSCHI) differ from the written language performance of adults with normal hearing (NH)? In section 2.3 five linguistic domains for analysis of the written answers were introduced. The results of the data analysis will be discussed for each of these linguistic domains.

[4] An example of such website: http://taaladvies.net/taal/advies/vraag/312/gedachtestreepje/ from the Dutch language union on the correct use of indents

3.2.1 Syntactic complexity

Figure 1 shows the median values for the main measures 'mean length of utterance in words' (MLU) and 'mean length of the 5 longest utterances in words' (MLUL) for the NH and MSCHI group.

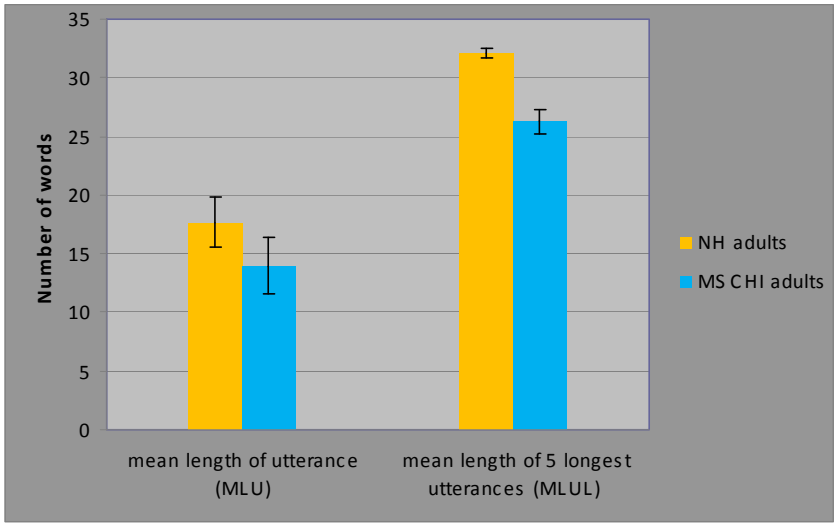

Figure 1: group median values of measures of syntactic complexity MLU and MLUL and standard error bars

The measures 'mean length of utterance' (MLU) and 'mean length of 5 longest utterances' (MLUL) were compared using the Mann-Whitney U-test. For the MLU measure, comparisons of the scores for the NH and MSCHI group showed no significant group differences [Mann-Whitney *U =51.000, n1=9, n2=20; p>0.05*]. The MLUL measure revealed a significant difference between the NH and MSCHI group [Mann-Whitney *U =41.000, n1=9, n2=20; p<0.02*].

Figure 2 shows the median values of the other measures of syntactic complexity for the MSCHI and NH groups, i.e. the occurrence of twelve syntactical categories. Data show similar performance for the two groups. For all measures data yielded no significant difference [Mann-Whitney *U = range from 63.000 to 88.500, n1=9, n2=20; p>0.05*].

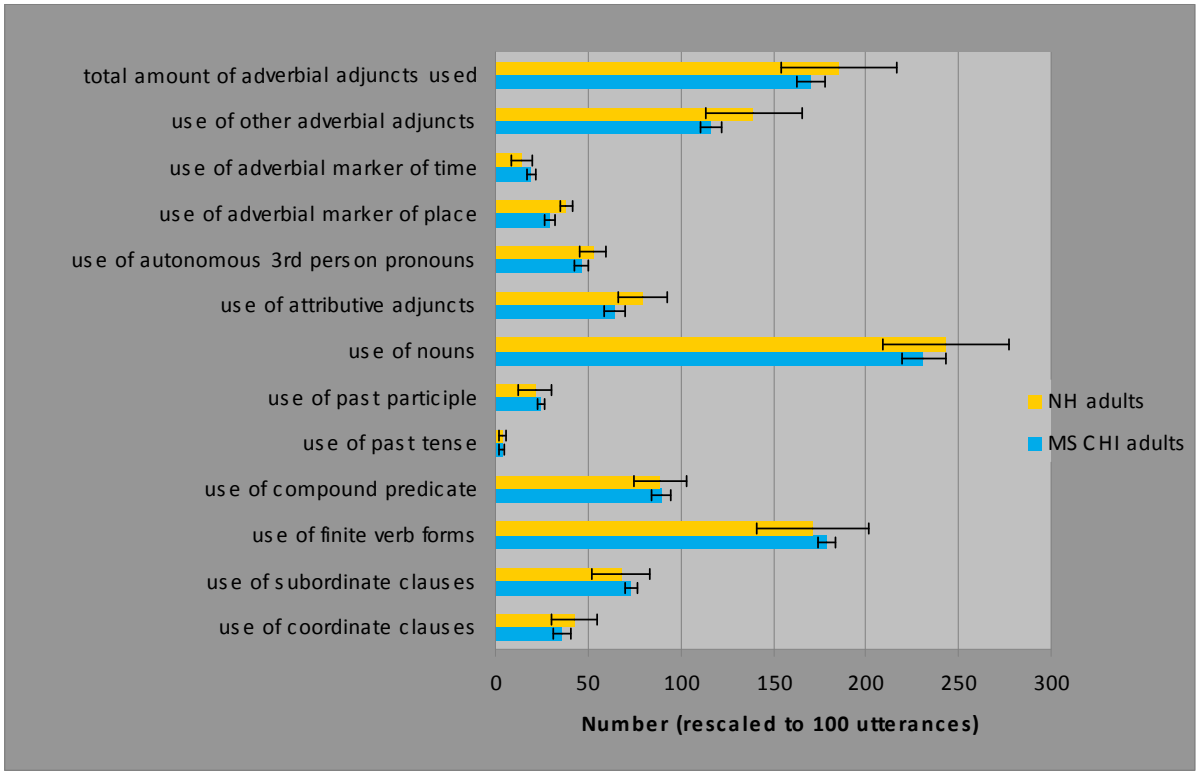

Figure 2: Median values for other measures of syntactic complexity and standard error bars

3.2.2. Morphosyntax

Figure 3 shows the median values for the NH and MSCHI group for the main measures for morphosyntax, i.e. 'number of ungrammatical utterances' and 'number of morphosyntactic errors'. No significant inter group difference was found [Mann-Whitney *U =84.500 'ungrammatical utterances', U =84.000 'morphosyntactic errors', n1=9, n2=20; p>0.05*].

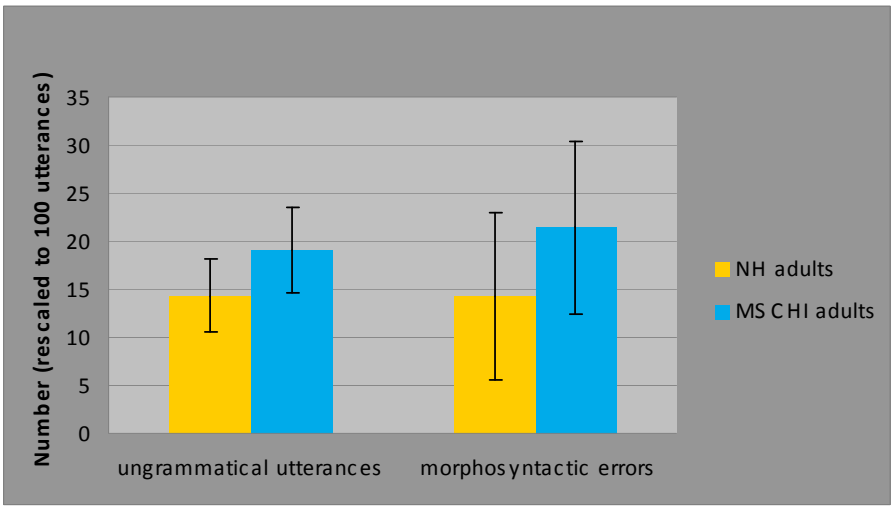

Figure 3: median values of main measures of morphosyntax and standard error bars

For the qualitative analysis of the morphosyntactic errors, error categories 'past tense error' and 'past principle error' were excluded from statistical analysis because these errors did not occur in the written samples. The median values of the remaining error categories for the NH and MSCHI group are shown in figure 4:

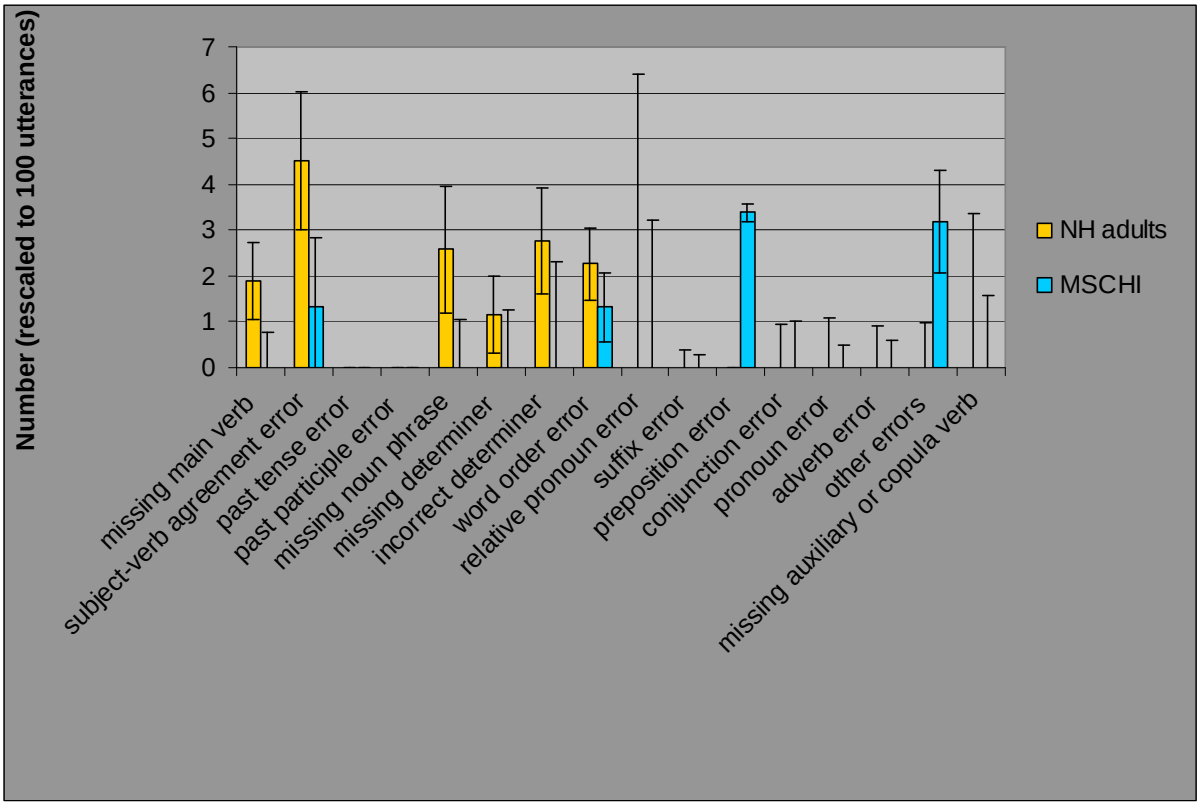

Figure 4: Median values of morphosyntactic error categories and standard error bars

Data show similar performance for the two groups. For all measures data yielded no significant difference [Mann-Whitney *U = range from 64.000 to 90.000, n1=9, n2=20; p>0.05*].

3.2.3. Semantics and pragmatics

Figure 6 shows the median variable values for the NH and MSCHI group for the measures for semantics and pragmatics:

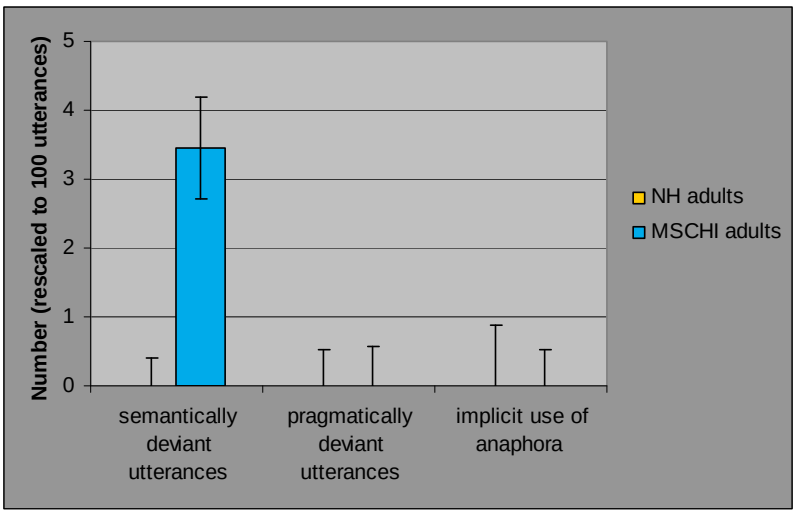

Figure 6: Median values of measures of semantics and pragmatics and standard error bars

The MSCHI group produced significantly more semantically deviant utterances compared to the NH group [Mann-Whitney *U =47.500, n1=9, n2=20; p<0.03*]. Regarding the measures 'pragmatically deviant utterances' and 'implicit use of anaphora' both groups performed similarly [Mann-Whitney *U =81.000, U =84.000, n1=9, n2=20; p>0.05*].

3.2.4. Modality specific items: Spelling and punctuation errors

Figure 7 shows the median values for the NH and MSCHI group for spelling and punctuation errors. No significant difference was found between the groups [Mann-Whitney *U =72.000, n1=9, n2=20; p>0.05*].

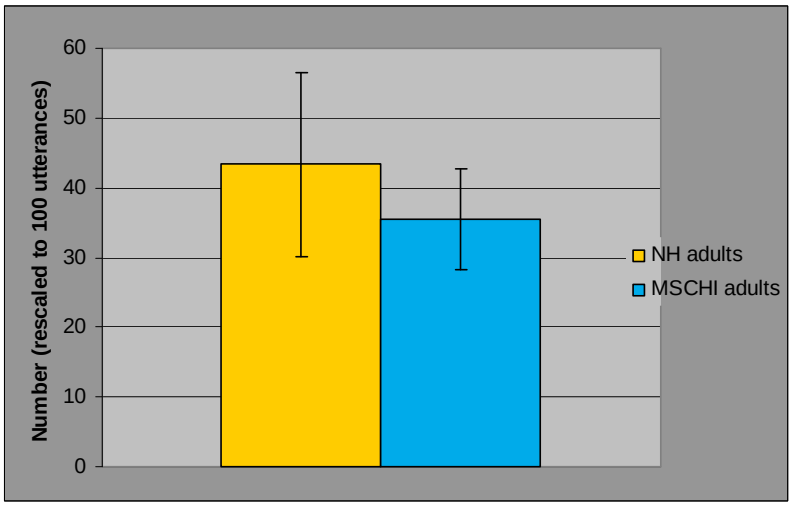

Figure 7: Median values of spelling and punctuation errors and standard error bars

3.3 Results of spoken language and written language performance of the MSCHI group

The second question the current study aims to answer (as mentioned in section 1) is whether the written language performance of the MSCHI individuals differs from their spoken language performance, as studied by Huysmans et al. (to appear).

The MSCHI group produced significantly more utterances in the spoken samples compared to the total number of utterances from the written samples [Mann-Whitney *U =39.500, n1=20, n2=20; p=0.000*], as shown by figure 8.

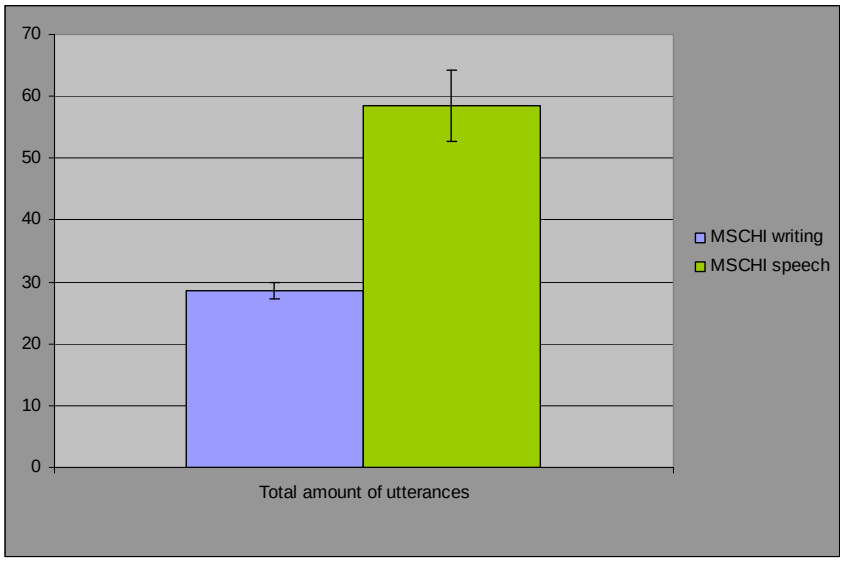

Figure 8: median value of number of utterance per writing and speech sample and standard error bars

3.3.1 Syntactic complexity

Figure 9 shows the median values for the MLU and MLUL measures. Utterances in the written samples were significantly longer than in the spoken samples [Mann-Whitney *U 'mean length of utterance' =25.500, n1=20, n2=20; p=0.000*]. The data for MLUL did not reveal a significant difference [Mann-Whitney U 'mean length of the 5 longest utterances in words' *=138.000, n1=20, n2=20; p=>0.05*].

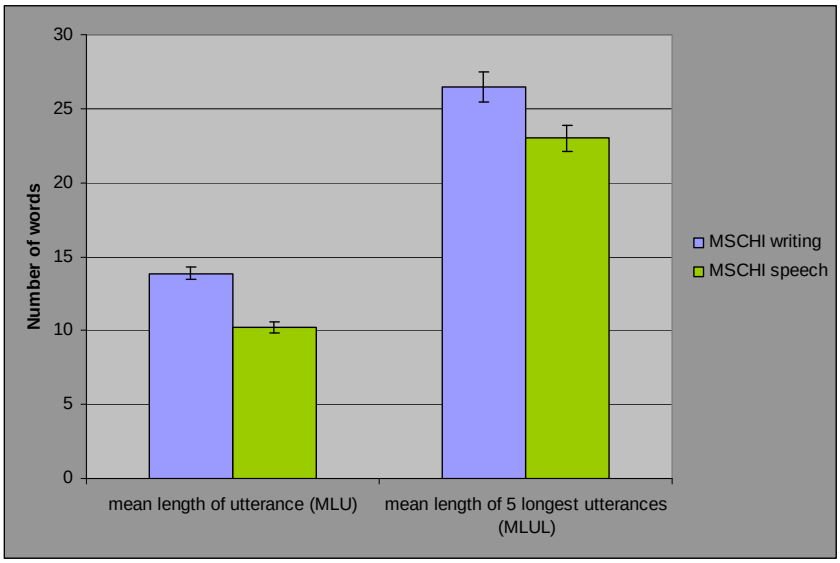

Figure 9: median values for the MLU and MLUL measures and standard error bars

The data for the other measures of syntactic complexity for the MSCHI group yielded a significant difference for 8 out of 13 measures. Figure 10 shows the median values for these other measures of syntactic complexity.

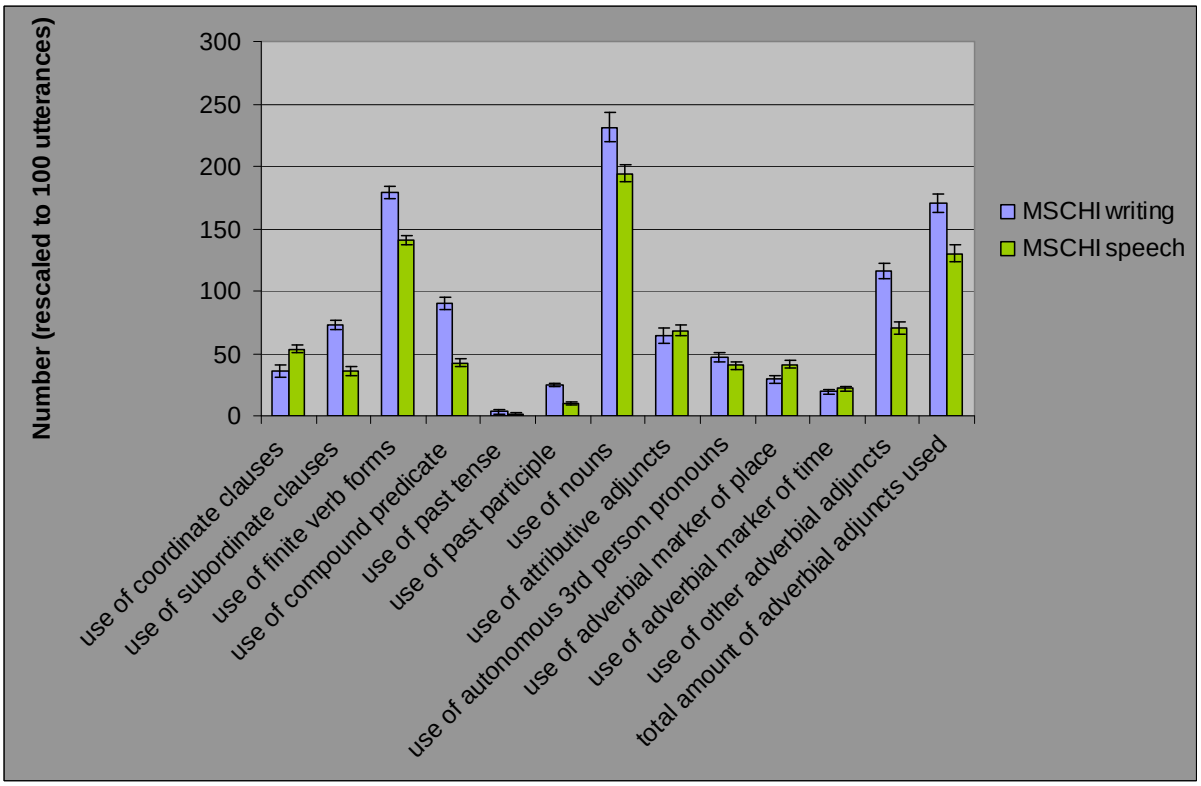

Figure 10: median values for these other measures of syntactic complexity and standard error bars

'Use of coordinate clauses', 'use of subordinate clauses', 'use of finite verb forms', 'use of compound predicate', 'use of past participle', 'use of nouns', 'use of other adverbial adjuncts' and 'total amount of adverbial adjuncts used' all occurred significantly more often in the written samples compared to the spoken samples [Mann-Whitney *U = range from 5.000 to 114.000, n1=20, n2=20; p<0.02*]. For the other five measures data yielded no significant difference [Mann-Whitney *U = range from 134.500 to 188.000, n1=20, n2=20; p>0.05*].

3.3.2 Morphosyntax

Figure 11 shows the median values for the categories of morphosyntactic errors of the written and spoken samples of the MSCHI group.

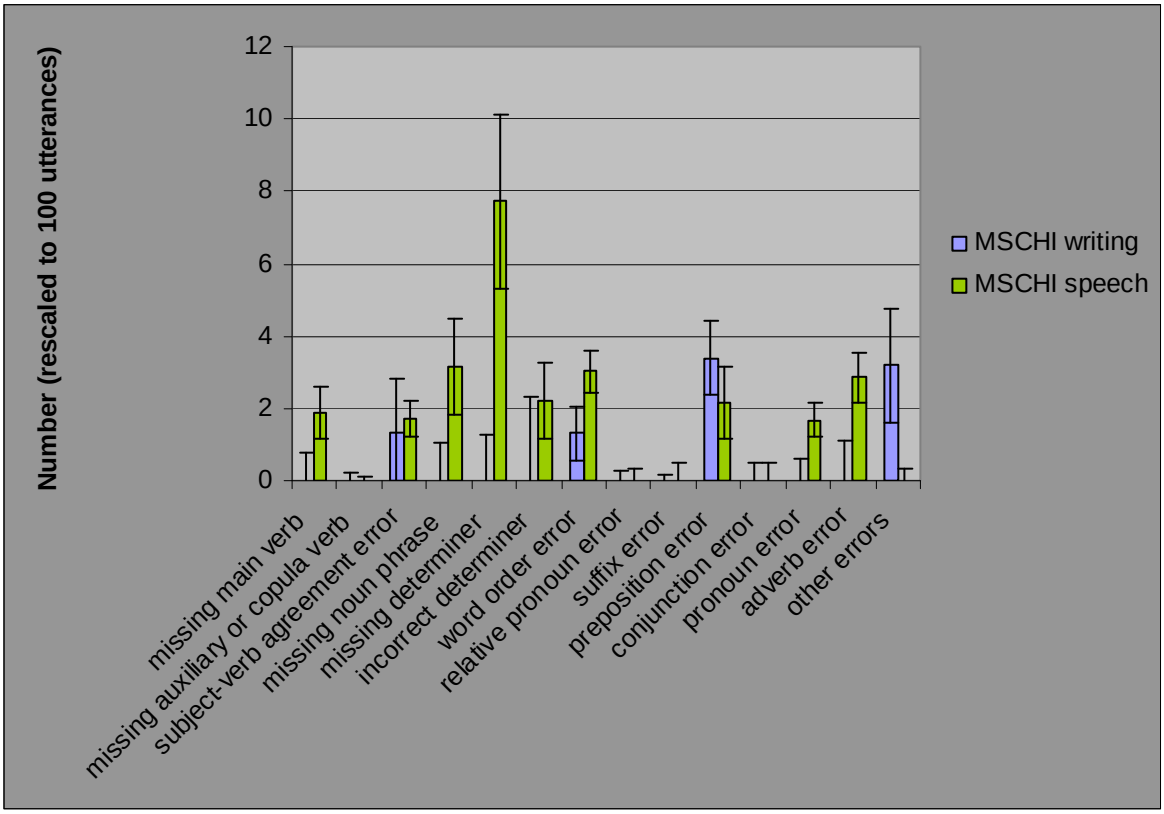

Figure 11: median values for the categories of morphosyntactic errors of the written and spoken samples of the MSCHI group and standard error bars

Several categories of morphosyntactic errors revealed a significant difference between the written language and spoken language performance of the MSCHI group: 'missing determiner', 'relative pronoun error', 'suffix error', 'pronoun error'

and 'other errors' [Mann-Whitney *U =117.000, U =136.000, U =141.000, U =110.500, U =116.000, n1=20, n2=20; p<0.04*]. All of these errors occurred more frequently in the spoken samples than in the written samples of the MSCHI subjects. For the other measures data yielded no difference between the written and spoken language performance of the MSCHI subjects [Mann-Whitney *U = range from 142.500 to 199.500, n1=20, n2=20; p>0.05]*.

3.3.3 Semantics and pragmatics

Figure 12 shows the median values for the semantic and pragmatic measures. The data revealed a significant difference regarding 'implicit use of anaphora'. The spoken samples contained significantly more 'implicit uses of anaphora' compared to the written samples [Mann-Whitney *U =135.500, n1=20, n2=20; p<0.05]*.

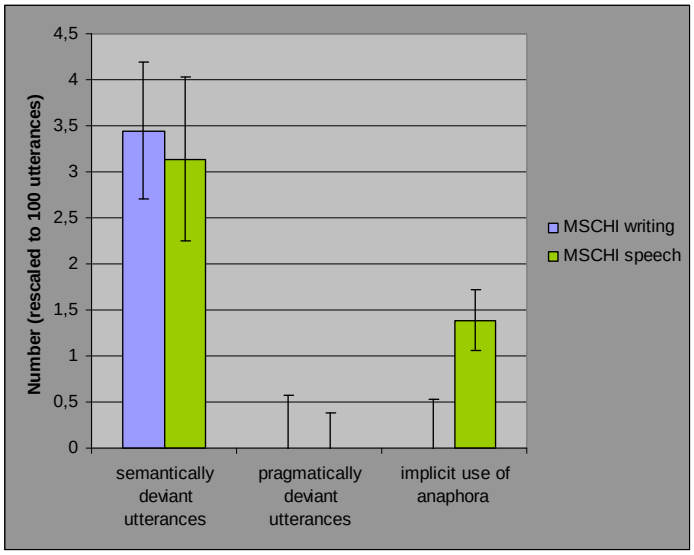

Figure 12: median values for the semantic and pragmatic measures and standard error bars

For the other two measures 'semantically deviant utterances' and 'pragmatically deviant utterances' data yielded no difference between the written and spoken language performance of the MSCHI subjects [Mann-Whitney *U =175.500, U =196.000, n1=20, n2=20; p>0.05]*.

3.4 Results of spoken language and written language performance of the NH group

Figure 13 shows the values for the total amount of utterances produced by the NH group in both written and spoken samples. The NH group produced significantly more utterances in the spoken samples compared to the total number of utterances from the written samples [Mann-Whitney *U =0.000, n1=9, n2=9; p=0.000*].

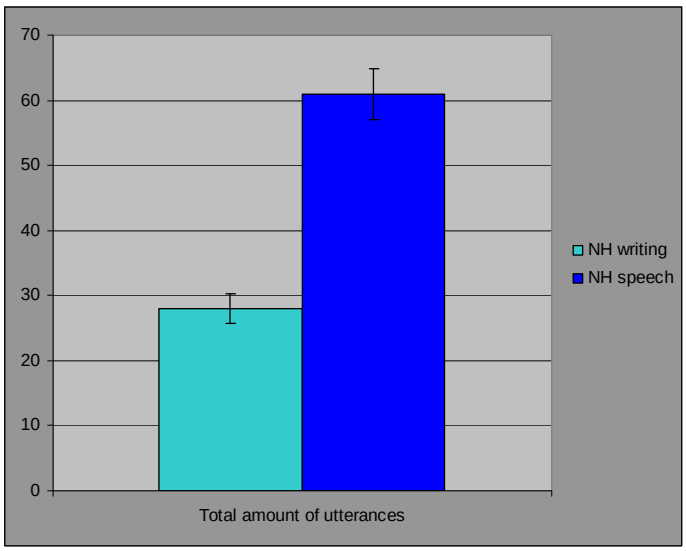

Figure 13: the values for the total amount of utterances produced by the NH group in both written and spoken samples and standard error bars

Figure 14 shows the values for the measures of syntactic complexity 'MLU' and 'MLUL'. Utterances were significantly longer in the written samples than in the spoken samples [Mann-Whitney *U 'mean length of utterance' =0.000, n1=9, n2=9; p=0.000*]. Furthermore a significant difference was found for the measure 'mean length of 5 longest utterances' (MLUL) [Mann-Whitney *U =18.000, n1=9, n2=9; p<0.05*].

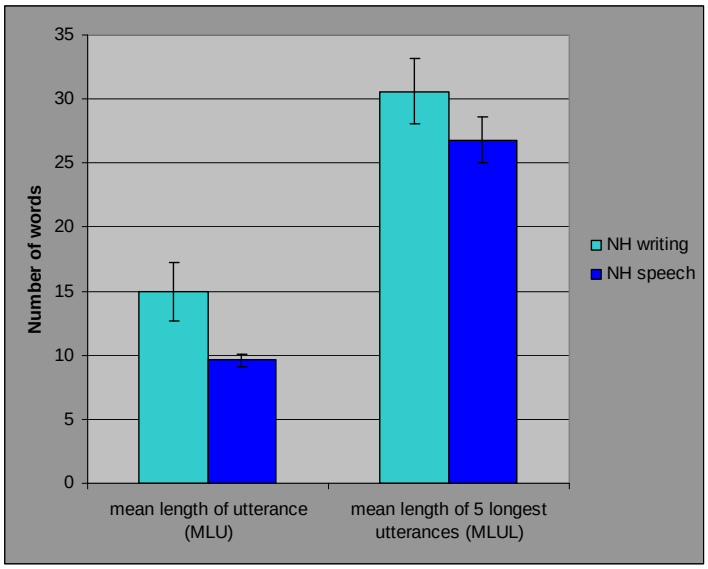

Figure 14: values for the measures of syntactic complexity 'MLU' and 'MLUL' and standard error bars

The data for the other measures of syntactic complexity for the NH group yielded a significant difference for 8 out of 13 measures. Figure 15 shows the median values for the other measures of syntactic complexity for the written and spoken samples of the NH group. 'Use of subordinate clauses', 'use of finite verb forms', 'use of compound predicate', 'use of past tense', 'use of past participle', 'use of nouns', 'use of other adverbial adjuncts' and 'total amount of adverbial adjuncts used' all occurred significantly more often in the written samples compared to the spoken samples [Mann-Whitney *U = range from 0.000 to 18.000, n1=9, n2=9; p<0.04*]. For all other measures data yielded no significant difference [Mann-Whitney *U = range from 22.000 to 38.000, n1=9, n2=9; p>0.05*].

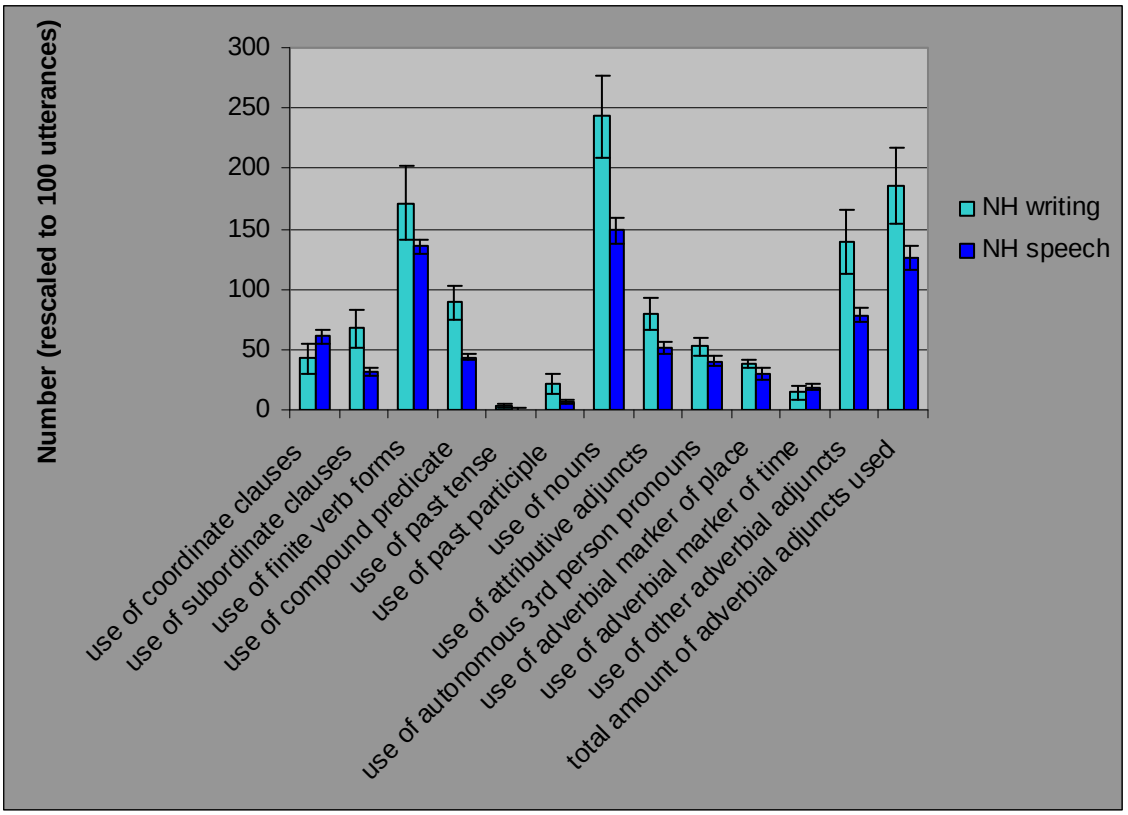

Figure 15: median values for the other measures of syntactic complexity for the written and spoken samples of the NH group and standard error bars

The linguistic domains of semantics, pragmatics and modality specific items did not reveal significant differences between the written and spoken language performance of the NH group.

4. Discussion and conclusions

This explorative study examined (1) whether the written language performance of adults with moderate to severe congenital hearing impairment (MSCHI) differs from that of normal-hearing adults (NH) at group level, and (2) whether the written language performance of MSCHI subjects differs from their spoken language performance at group level, as studied by Huysmans et al. (to appear). Written language performance was examined by analysing written samples in the expository discourse genre. The results of the 20 MSCHI adults and 9 NH adults were analysed using the STAP method (Dungen & Verbeek, 1999) and additional modality specific items.

The data on written language performance for the MSCHI and NH group reveal that written performance does differ between the MSCHI and NH adults at group level for the measures 'mean length of the 5 longest utterances in words' (MLUL) and 'semantically deviant utterances'. For the other measures from the linguistic domains used for analysis, comparisons yielded no significant group differences.

The data on written language performance and spoken language performance within the MSCHI group show significant differences at group level for several linguistic domains. The MSCHI group produced utterances with a significantly longer mean length in the written samples compared to the spoken samples. Additionally several other measures of syntactic complexity occurred significantly more often in the written samples compared to the spoken samples. In the area of pragmatics, spoken samples contained considerably more 'implicit uses of anaphora' compared to the written samples. Furthermore, morphosyntax several categories were found to differ significantly between the spoken and written samples. 'Missing determiner', 'relative pronoun error', 'suffix error', 'pronoun error', 'other errors' and 'implicit use of anaphora' occurred substantially more frequent in the spoken samples than in de written samples of the MSCHI subjects. Other linguistic domains did not reveal significant differences.

When comparing the results from the present study with the outcomes of previous studies it is important to be aware of the general difference in study population. As the present study evaluates the performance of adults with moderate to severe hearing impairment, results may differ from the results of earlier studies on the performance of profoundly hearing-impaired individuals.

A comparison of written language performance in the MSCHI and NH group revealed a significant difference at group level for variables of two linguistic domains. Firstly, analysis of written language output in the present study revealed a significant difference regarding the measure of syntactic complexity 'mean length of the 5 longest utterances in words' (MLUL). Secondly, a significant difference between the written samples of the MSCHI and NH group was found regarding the median value of semantically deviant utterances.

Measures of three different categories were used to estimate syntactic complexity of the written samples: 'mean length of the 5 longest utterances in words' (MLUL), 'mean length of utterance' (MLU) and 'other measures of syntactic complexity'. The 'mean length of the 5 longest utterances in words' (MLUL) of the MSCHI group was significantly shorter in length than the MLUL of the NH group. The other two measures 'mean length of utterance' (MLU) and 'other measures of syntactic complexity' did not reveal a significant difference.

There are several possibilities regarding the interpretation of a significant difference for MLUL. Zhu (2007) notes that syntactic maturity can be measured by objective measures such as MLUL. Opposite to this view, Eisenberg et al. (2001) point out that longer utterances are not necessarily more syntactically sophisticated than shorter ones, and grammatically more advanced utterances are not necessarily longer than less advanced ones. Thus, MLUL alone is not a sufficient measure of syntactic complexity. The present research measured syntactic complexity not only based on MLUL, but also on MLU and other measures of syntactic complexity. These last two categories of measuring syntactic complexity did not show significant differences. As MLUL is not a sufficient measure of syntactic complexity, it would be incorrect to conclude from only a difference in MLUL that the MSCHI group showed less syntactic maturity. However, one can hypothesize that the length of the MLUL is influenced by an

individual's level of self-assurance regarding written language performance. As MacArthur et al. (2008) note, children with well-developed spoken language would theoretically develop writing more efficiently and should show a faster progress because these children would likely rely on their spoken knowledge of language while writing. Children with hearing-impairment whose spoken language is not as well developed as the spoken language of their normal-hearing peers would then show a poorer writing performance compared to these hearing peers. As a result, the children with hearing-impairment may show an everlasting lower self-assurance in writing performance. This is in accordance with Robier (2001 In: Delage and Tuller, 2007) who noted that hearing impairment causes an atypical development in childhood, which may have long-lasting effects. Future research should contribute to the knowledge on the influence of self-assurance on the mean length of utterances, using an adaptation of the method of the present study. The main focus should be on the act of writing: do subjects with hearing-impairment make more self-corrections and erasures compared to normal-hearing subjects? Results may reveal a need for adaptation of education of children with hearing-impairment.

A second significant difference was found regarding semantically deviant utterances. At group level, the MSCHI group produced significantly more semantically deviant utterances compared to the NH group. Most semantic deviant utterances of the MSCHI group contained 'mismatches' or 'not commonly used words' which caused the utterances to be multi interpretable. For example in commonly used expressions, the choice of a different verb may cause the expression to be incorrect. The difference found on semantically deviant utterances is remarkable. To the knowledge of the authors of the present study semantics have not yet been studied in regard to the difference between the writing performance of hearing-impaired and normal-hearing adults. Nation and Snowling (1998) noted that semantic processing abilities interact with phonological processing. The authors investigated semantic processing abilities in normal-hearing children with reading comprehension difficulties by performing a receptive reading comprehension test. If weak phonological

processing abilities result in weak semantic processing abilities, individuals with hearing impairment are expected to show weaker semantic processing abilities compared to individuals with normal hearing. Ormel et al. (2010) found that semantic-categorical knowledge of deaf children indeed appears to be less precise or less finely differentiated than the semantic-categorical knowledge of hearing children. Ormel et al. found limited improvement across grade levels, which indicates that even in adulthood semantic categorization would remain less precise or less finely differentiated. It has to be noted that Ormel et al. performed a receptive reading comprehension test and not a writing production test. However, the present study did find a poorer performance on semantically deviant utterances of the MSCHI group compared to the NH group. Therefore, one could hypothesize that weak phonological processing abilities result in weak semantic processing abilities in both receptive and production tasks, not only in childhood but also in adulthood. A possible explanation may be found in semantic networks in the brain. Prior to being able to produce a word, one has to connect a semantic representation of a concept or association to its phonological form. This process of word production is relatively sensitive to impairment (Järvelin et al., 2006). The use of 'mismatches' and 'not commonly used words' indicates that the connections in the semantic network are inaccurate. If the cause of the significant difference in semantically deviant utterances lies in the field of semantic networks, such difference would also be expected to be found in comparison with the spoken language performance of the MSCHI and NH group at group level. However, no significant difference occurred regarding semantically deviant utterances in the recent study by Huysmans et al. (to appear) on spoken language performance. Additionally, Ormel et al. (2010) studied deaf children and not adults with moderate to severe hearing impairment. Therefore it is unlikely that the cause of the significant difference of semantically deviant utterances in writing for the MSCHI group lies in a problem of the semantic network. Further research is needed to clarify this difference in semantically deviant utterances in the writing of the MSCHI group at group level.

It is important to note that the relatively few differences found in the present study between the written language performance of the MSCHI and NH group are not in accordance with the outcomes of previous studies on this topic. The MSCHI adults from the present study showed a relatively good performance regarding morphosyntax and punctuation, whereas adults with hearing impairment in previous studies did not. Comparing the writing of deaf and hearing students, Channon and Sayers (2007) found that deaf students demonstrated low mastery of several morphosyntactic items and punctuation. Research reported by Gormley and Sarachan-Deily (1987, In: Luckner & Isaacson, 1990) suggests that writers with severe to profound hearing impairment make more spelling, punctuation and grammatical errors compared to writers with normal hearing. These differences are known to be caused by a delay in spoken language development in hearing-impaired individuals, which has an adverse effect on the development of written language (Luckner & Isaacson, 1990). The MSCHI adults of the present study have moderate to severe hearing impairment, whereas the previous studies mainly investigated the written language performance of profoundly hearing-impaired individuals. This explains the difference between the results found for the written language performance of the MSCHI group and the previous studies on this topic.

However, in the recent study on spoken language performance of the same groups (Huysmans et al., to appear) the MSCHI adults did show a poorer morphosyntactic performance at group level compared to the NH group. This difference was however not reflected in the written language performance comparison at group level of the MSCHI and NH group. This indicates that the MSCHI adults benefit from the modality specific characteristics of writing, such as absence of pressure of online processing, more time to deliberate and revise and a better access to vocabulary. These modality specific characteristics allow the MSCHI adults to correct morphosyntactic errors, as self-correction of written language output does not require hearing, but vision. Since MSCHI adults have a hearing impairment, and not a visual impairment, they are able to correct morphosyntactic errors in written language output. In spoken language errors are not clearly heard by the MSCHI adults and therefore they do not succeed to

correct these errors. Furthermore, spoken language lacks the modality specific characteristics of writing which cause a benefit for the MSCHI adults in their written language performance.

Besides the benefit from the modality specific characteristics of writing the MSCHI adults may also benefit from another aspect related to written language. Hearing-impaired individuals most likely compensate their spoken language difficulties by relying on written language. Writing is part of speech-language therapy for children with hearing impairment. As a result individuals with hearing impairment are able to use written support as a compensation of phonological problems (Delage & Tuller, 2007).

The results of the recent study on spoken language performance are not caused by a difference in language competence at group level between the MSCHI and NH group. Without the pressure of online processing the difference in performance of both groups decreases. Once again, this does not indicate a deficit in language competence, but it indicates a disadvantage of hearing impairment in auditory processing resulting in a poorer spoken language performance for the MSCHI adults. This however does not imply that on an individual level of analysis no deficit in language competence could be found. The present study analyzed data at group level. Further research on differences in performance on individual level is needed to determine whether the results found at group level are also reflected in analysis at individual level.

The benefit from the modality specific characteristics of writing explains the better performance on several measures of syntactic complexity for both the MSCHI and NH group in written samples compared to spoken samples. However, it should be noted that utterances were rescaled to 100 utterances per sample. The present study on written language performance may consist of a smaller sample size than the study on spoken language performance (Huysmans et al., to appear). Therefore the better performance on several measures of syntactic complexity may also be caused by this difference in sample size between both studies and the necessary rescaling. Future studies on this topic should adapt their method to ensure equal sample sizes for both written and spoken language.

In comparison between spoken and written language performance the MSCHI group showed a better written language performance compared to their spoken language performance. Syntactic complexity is found to be greater in written language than in spoken language (among others: O'Donnell, 1974). As mentioned, writing allows revision and deliberation. The absence of the pressure of online processing allows a better access to vocabulary and frees writers from limitations of short-term memory or the ability to concentrate. This also leads to longer utterances in written language than in spoken language. Spoken utterances are influenced by the short-term memory and the speaker's ability to concentrate. Writers are influenced by such factors and therefore tend to produce sentences of strikingly longer length (Chafe et al., 1987). Therefore it is not surprising that a difference in MLUL was found between the written and spoken language performance of both the MSCHI and NH group. Data revealed that 8 out of 13 other measures of syntactic complexity occurred significantly more often in the written samples compared to the spoken samples at group level for both the MSCHI and NH group. This supports the notion that syntactic complexity is found to be greater in written language than in spoken language. More specifically, it supports the notion that written language contains more subordinate and adverbial clauses, longer and more complex utterances and higher values for mean length of utterance (O'Donnell, 1974). However, as mentioned before, the number of utterances to be analysed for each sample was rescaled to 100 utterances. This may cause a bias in the interpretation of these data. An additional analysis of the written and spoken samples is needed to determine whether significant differences regarding other measures of syntactic complexity also continue to exist when absolute data are used for analysis.

As noted by MacArthur et al. (2008) written language performance may influence spoken language performance. Writing can make certain aspects of language more noticeable to the learner. This study has shown a better written language performance of adults with moderate to severe congenital hearing impairment at group level compared to their spoken language performance at group level. Written language performance at group level mainly differed from spoken language performance at group level on the linguistic domain of

morphosyntax. This difference in performance is not caused by a deficit in language competence but by the difference in processing. However, as mentioned before, this is only true for language performance at group level. Further research is needed for analysis at individual level. Data show that both groups show similar written language performance at group level, caused by a benefit for the MSCHI group due to the modality specific distinctions of writing. Because of this benefit, the significantly poorer spoken language performance at group level of the MSCHI group compared to the NH group (as studied by Huysmans et al., to appear) was not reflected in their written language performance. As written language may influence spoken language, education and therapy for children with hearing impairment should have a greater focus on written language.

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Appendix A

Applied variable set, adapted from the STAP method (van den Dungen and Verbeek, 1999), adapted for analysis of written samples:

A. Syntax

Main measures:

1. T-units (Dungen & Verbeek, 1999)
2. MLU: mean length of utterance, in words (STAP)
3. MLUL: mean length of 5 longest utterances, in words (STAP)

Qualitative measures (STAP):

Use of coordinate clauses, finite verb forms, compound predicates, past tense, past participle, nouns, attributive adjuncts, autonomous 3rd person pronouns, adverbial markers of place, adverbial markers of time, and use of other adverbial adjuncts

B. Morphosyntax

Mean measures:

a. number of ungrammatical utterances: number of utterances with one or more morphosyntactic errors
b. number of morphosyntactic errors

Qualitative measures (STAP):

Word order error, missing main verb, missing noun phrase (subject and/or object), subject-verb agreement error (excl. missing auxiliary or copula verb), missing determiner, incorrect determiner, past tense error, past participle error.

C. Semantics

Mean measures:

a. semantically deviant utterances: sum of all moderately and severely semantically deviant utterances (STAP)

D. Pragmatics

Mean measures:

a. pragmatically deviant utterances: sum of all moderately and severely pragmatically deviant utterances (STAP)
b. implicit use of anaphora (STAP)

E. Modality specific items

Qualitative measures:

Spelling, punctuation (avoidance/overuse), capitalization (Gregg et al., 1991)