Chapter 3

Morphosyntactic Correctness of Written Language Production in Adults with Moderate to Severe Congenital Hearing Impairment

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ABSTRACT

Objective: To examine whether moderate to severe congenital hearing impairment (MSCHI) leads to persistent morphosyntactic problems in the written language production of adults, as it does in their spoken language production.

Design: Samples of written language in Dutch were analysed for morphosyntactic correctness and syntactic complexity.

Study Sample: 20 adults with MSCHI and 10 adults with normal hearing (NH)

Results: Adults with MSCHI did not differ from adults with NH in the morphosyntactic correctness and syntactic complexity of their written utterances. Within the MSCHI group, the number of morphosyntactic errors in writing was related to the degree of hearing impairment in childhood.

Conclusions: At the group level, MSCHI does not affect the morphosyntactic correctness of language produced in the written modality, in contrast to earlier observed effects on spoken language production. However, at the individual level, our data suggest that adults who acquired their language with more severe auditory limitations are more at risk of persistent problems with morphosyntax in written language production than adults with a lower degree of hearing impairment in childhood.
INTRODUCTION

For adults’ participation in daily life, adequate communication in both speech and writing is important. Writing differs from speech as it can be planned and changed through revision before someone reads it. Whereas typically developing children acquire full mastery of spoken language without explicit instruction, mastery of written language requires formal instruction. In alphabetic writing systems, phonological awareness plays an important role. Because the acquisition of a spoken language, the development of phonological skills, and the comprehension of oral instructions all depend on auditory perception, development of literacy is at risk in people who are born with hearing impairment (Moeller et al., 2007). Thus far, little is known about the long-term effects of moderate to severe congenital hearing impairment (MSCHI) on writing achievement in adults. Therefore, in addition to earlier published data on the effect of congenital hearing loss on the spoken language production of an adult population with MSCHI (Huysmans et al., 2014), this article examines the impact of MSCHI on the morphosyntactic correctness of Dutch language production in the written modality in the same study population. Hence, the performance of a group of adults with MSCHI is compared to the performance of a reference group with adults with normal hearing (NH).

When a child has congenital hearing impairment (CHI), the development of an oral language is at risk. The linguistic area of morphosyntax was found to be most vulnerable when language is acquired with degraded auditory input (e.g., Tomblin et al., 2015), while deficiencies in phonology, lexicon, and pragmatics were reported in CHI children as well (see Moeller et al., 2007, for an overview). Difficulties in phonology and morphosyntax were shown to persist into adolescence in a population with mild to moderate CHI (Delage & Tuller, 2007). In the adults with moderate to severe CHI of the current study, morphosyntactic problems in the production of spoken language were confirmed to persist into adulthood (Huysmans et al., 2014). Research has shown that inter-individual differences of the consequences of hearing impairment in childhood on linguistic abilities can (partly) be explained by ‘the inconsistent access account’: factors that define the extent to which access to and perception of language is affected, predict individual language outcomes (Moeller & Tomblin, 2015). In a large study in children with mild to severe hearing loss, the severity of the hearing impairment in childhood was shown to be one of these factors, as well as the outcomes of auditory rehabilitation (Tomblin et al., 2015). In the studies with adolescents (Delage & Tuller, 2007) and adults (Huysmans et al., 2014), the degree of CHI was related to the participants’ morphosyntactic abilities. As the current study concerns the same study population as in Huysmans et al (2014), we now examine whether the degree of CHI is also associated with the MSCHI adults’ language production performance in the written modality.

Deviations in the linguistic performance of adults with MSCHI may be associated with their hearing ability during language acquisition, but also with their hearing ability at the moment of assessment. In a separate study, we examined these two possible sources of impediment.
by comparing performance in spoken language production of NH adults, adults with MSCHI, and adults who acquired hearing impairment (AHI) after childhood (Huysmans et al., 2016). Whereas the MSCHI adults did not differ from the AHI adults in their hearing ability at the moment of testing, they differed in hearing ability during language acquisition: AHI adults were normal-hearing when acquiring language, while MSCHI adults were not. In contrast to the adults with MSCHI, who made more errors in their spoken output than the NH adults, the AHI adults performed within the range of the NH adults. This finding implies that deviances in the spoken performance of adults with MSCHI are likely to be attributed to auditory limitations during language acquisition, and not to perceptual limitations at the moment of testing. Studying which linguistic difficulties persist into adulthood in a population with CHI yields valuable information about the language-specific structures that are particularly vulnerable when language is acquired with impaired hearing. This information, derived from adults, may advance the selection of specific goals for language rehabilitation in young hearing-impaired children, and is relevant for clinical practice. Hence, examining the linguistic performance of adults with CHI is of additional value to the research in the field.

Earlier, the MSCHI adults of this study showed specific difficulties in their spoken production of Dutch with the use of determiners in an obligatory context, present tense markers, and adverbs (Huysmans et al., 2014). This error pattern seemed to reflect the selective effect of the adults’ hearing impairment on the acquisition of Dutch morphosyntax. Because grammatical markers that are low in auditory perceptual salience (i.e., linguistic structures that are hard to hear) are at risk when acquired with degraded auditory input (McGuckian & Henry, 2007; Svirsky et al., 2002), this could explain errors in the use of low salient markers like Dutch determiners, present tense markers, and the adverb er. In addition, language-specific aspects that are grammatically relatively complex may be more difficult to acquire when the intake of linguistic input is affected by hearing impairment. This could explain errors in the correct use of pronominal adverbs, as this is considered to be a complex issue in Germanic languages (Belz, 2005; van Canegem-Ardijns & van Belle, 2005). The impact of MSCHI on spoken language production was not only characterised by its selectivity, but also by the adults’ variability in performance: a specific morphosyntactic structure was used correctly in one utterance, while an error was made in another utterance. Huysmans et al. (2014) interpreted this finding in view of the ‘vulnerable marker hypothesis’, formulated by Bishop (1994) when discussing the linguistic performance of children with specific language impairment. According to this hypothesis, problems in the expression of morphosyntactic markers that are vulnerable in the process of language acquisition may surface when communication demands challenge the language production system. For the MSCHI population, the rationale of the vulnerable marker hypothesis thus predicts that errors in language production under straining conditions are not random, but reflect aspects of morphosyntax that are vulnerable when acquired with degraded auditory input. We now examine whether these selective morphosyntactic difficulties also surface in the MSCHI adults’ language production in the written modality.
The impact of CHI on the written language production of adults has been the topic of a limited number of studies. Earlier research has focused on adults with a more substantial degree of CHI than the participants in the current study, some of them using a sign language as well as a spoken language for communication. Fabbretti et al. (1998) studied samples of written language in adults with profound CHI who used Italian and Italian Sign Language and had relatively low familiarity with written discourse. In their data, specific difficulties in the written language production of the adults with profound CHI reflected the impact of the participants’ auditory limitations on the access to and the acquisition of grammatical morphology. The adults with profound CHI produced significantly more errors than NH adults and showed a selective difficulty with grammatical aspects of Italian that can only be identified through hearing, while visual information is less reliable. Compared to the performance of NH adults who were bilingual in Italian and Italian Sign Language, the errors in the writing of adults with profound CHI could not be explained by interference from Italian Sign Language. Compared to the performance of NH adults with poor schooling, limited experience with written Italian could not solely account for the hearing-impaired adults’ error pattern either. Thus, this research showed that problems in the use of grammatical aspects that are difficult to perceive auditorily, surface in the written language production of adults with profound CHI. Vollmann et al. (2002) analysed faxes written in German that were sent to health services by adolescents and adults (ranging in age from 15 to 60 years) with prelingual deafness. Analysis comprised identification of errors on lexicon, morphology, and syntax. In the written language samples, errors in nominal morphology were most apparent, followed by errors in verbal morphology, and then in syntax. Their data confirmed that the deployment of morphosyntax in written language production is vulnerable in individuals with CHI. The authors did not discuss the possible influence of knowledge of the grammar of a sign language on the deployment of morphosyntax in the written representation of the oral language. For the Dutch language, as assessed in the current study, earlier research was done on the writing of children (11 and 12 years), adolescents (15 and 16 years), and adults with severe to profound CHI (van Beijsterveldt & van Hell, 2010). The participants varied in their level of proficiency in Sign Language of the Netherlands. Analysis of the participants’ writing focused on noun phrase morphosyntax, as this aspect is known to be difficult for deaf children to acquire. In the written samples of the subjects with severe to profound CHI, errors in noun phrase morphology occurred more often than in the written samples of their NH peers. The CHI subjects’ error rate decreased with age, but errors nevertheless persisted into adulthood. Interference from sign language grammar on noun phrase morphosyntax was observed in the performance of the children and adolescents, but not in the adults’ performance. Differences in the linguistic background of the age groups were hypothesised to account for this finding. In their writing, subjects with severe to profound CHI showed a significant number of noun phrase-internal errors like omissions of obligatory articles and determiner errors regarding gender or number agreement. Moreover, the CHI subjects often omitted noun phrases in obligatory contexts. These three error categories are also included in the assessment of the current study. Thus, we expect our data to reveal whether problems of this kind also hold for
adults who acquired Dutch with less severe auditory limitations and who have no knowledge of a sign language. Overall, previous research thus confirms that morphosyntactic correctness in written language production is prone to be affected by severe to profound CHI, while the specific errors reflect the consequences of auditory limitations on the acquisition of grammatical morphology.

Language production in the spoken and written modality differ in linguistic processing and cognitive demands. When comparing models on language production processing in the two modalities (Chenowith & Hayes, 2001; Levelt, 1999), one can derive that writers may benefit from modality-specific conditions that release strain on the processing capacity of the language production system: language production through writing is less restricted in time than spoken language production, and processing in writing is performed in recurring cycles of revision until the writer is satisfied with the output (Chenowith & Hayes, 2001). The offline character of writing allows for the deployment of explicit linguistic knowledge, offering the writer an additional tool to optimize the output (Williams, 2012). These modality-specific benefits lead to the prediction that errors are less likely to occur in writing than in speech. The output that results from speaking and writing also generally differs with regard to syntactic complexity: utterances in the written modality are generally syntactically more complex than in the spoken modality (Poole & Field, 1976; Redeker, 1984). Higher syntactic complexity in written language production is assumed to increase pressure on morphosyntactic correctness. Hence, the written language samples of the participants in this study are additionally examined for syntactic complexity. Analysis includes a paired comparison for the outcomes for syntactic complexity between modalities to examine the hypothesis that participants’ utterances are syntactically more complex in writing than in speech.

Summarizing, previous studies in adults with severe to profound CHI have found error patterns in writing that are assumed to reflect the impact of the participants’ auditory limitations on the acquisition of grammatical morphology. The current study examines whether comparable effects are found in the writing of a group of adults with moderate to severe CHI by comparing their performance to that of a NH reference group. In the MSCHI population of this study, earlier research has showed selective morphosyntactic difficulties in spoken language production with aspects that are at risk when acquired with degraded auditory input. The current study focuses on these apparent vulnerable markers and examines whether these specific difficulties also occur in the written language production of the MSCHI adults. In addition, within the MSCHI group, we examine whether the frequency of occurrence of morphosyntactic difficulties is associated with the degree of CHI.
MATERIALS AND METHOD

Participants

The data of this study were collected from the same group of subjects as in the earlier study on spoken language production (Huysmans et al., 2014). An overview of the participant characteristics is given in Appendix A. In the reference group with normal hearing (NH), 10 adults participated (7 females, 3 males), with a mean age of 25 years (range 20 to 34 years, SD = 5 years). In all NH participants, the pure tone average (PTA(0.5, 1, 2 kHz), i.e., mean hearing threshold at 0.5, 1, and 2 kHz) did not exceed 20 dB HL at the best ear. The group of participants with moderate to severe congenital hearing impairment (MSCHI) consisted of 20 adults (10 females, 10 males), with a mean age of 28 years (range 20 to 45 years, SD = 7 years). In the MSCHI group, the participants’ first known PTA(0.5, 1, 2 kHz) of the best ear (unaided) ranged from 37 to 93 dB HL (mean = 64 dB HL; SD = 19 dB HL). Because the aim of the study was to examine whether moderate to severe hearing impairment in infancy and childhood influences the linguistic performance in adults, anamnestic or audiometric indications were required to support the assumption that a participant was born with bilateral moderate to severe hearing impairment. The terms ‘moderate to severe’ in the abbreviation MSCHI thus refer to the level of congenital hearing impairment, reflecting the auditory possibilities during the critical period for language acquisition. All participants reported to have been diagnosed with hearing impairment during the first years of life, between the age of 9 months and 4;6 years, and all reported that their hearing was not better before diagnosis. All but one received hearing aids before the age of 5. Sixteen MSCHI participants received speech and language therapy during childhood to support their language development. Part of the subjects attended schools for children with hearing impairment, while others attended mainstream schools (see Appendix A for details). At the moment of participation in this study, the MSCHI participants’ best ear PTA(0.5, 1, 2 kHz) (unaided) ranged from 35 to 108 dB HL (mean = 77 dB HL; SD = 22 dB HL). All participants used hearing aids or a cochlear implant. Participants were raised in Dutch in a monolingual context, used spoken language to communicate in daily life, and reported not to have been in contact with users of a sign language during their school years. Consequently, the participants’

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1 Given the age of the participants, collection of audiometric data to define the level of hearing impairment early in life was not always successful. For 16 of 20 participants, audiometric data were available to define their level of hearing impairment early in life. For the other 4 participants, data for the level of hearing impairment at a young age were derived from more recent audiometric data as they indicated that their hearing loss had not changed since childhood. The variable ‘First known PTA(0.5, 1, 2 kHz) of the best ear’ in the MSCHI group therefore reflects oldest available (n = 16) or derived (n = 4) data.

2 One participant did not use hearing aids until the age of 18 because of a steep slope in his audiogram.

3 In the period in which the MSCHI participants of this study attended primary and secondary school, sign language was not used in Dutch schools for the hearing-impaired to interact with children who did not have profound hearing impairment.
development of Dutch was not influenced by the grammar of another language. Participants for the NH group were included according to their level of education to reflect the distribution of levels of education within The Netherlands (CBS, 2010). For the MSCHI group, our options for inclusion based on level of education were rather limited because of the relatively low number of candidates. Hence, the groups differ in the distribution of level of education of the participants. This may influence the outcomes of group comparisons for writing performance, as written language production is established following instruction in an educational context. An additional analysis was therefore carried out to examine the effect of level of education on the outcomes. NH participants were recruited through advertisements on flyers and posters. Participants with impaired hearing enrolled in the study after accepting an invitation of the audiology clinic where they were patients. The ethics committee of the VU University Medical Center Amsterdam approved the study. All participants provided written informed consent.

**Method**

By filling out a questionnaire, participants provided information regarding their hearing, their educational career, and the linguistic region in which they grew up. They were assessed with a task eliciting spoken language production (i.e., Favourite Game or Sports Task (Nippold et al., 2005a)) and with a task eliciting written language production, both encouraging the use of expository discourse, i.e., a genre in which language is used “to explicate facts and share complex knowledge in extended discourse units” (Paul, 2010, p. vii). Compared to conversational or narrative discourse, expository discourse is known to elicit syntactically more complex language in both modalities (e.g., Berman & Nir-Sagiv, 2004; Nippold et al., 2005a; Nippold et al., 2008; Schick, 1997; Verhoeven et al., 2002) and is a more sensitive detector of syntactic deficits in the spoken modality (Nippold et al., 2008; Scott & Windsor, 2000). Details of the elicitation procedure for spoken language production are given in Appendix E. To obtain a sample of written language production, the participants were asked to write a reaction to the following prompts:

1. You get the chance to go on a holiday and can pick two people to join you. Which two persons would be the best to accompany you? Explain why you would pick them. Imagine your passport and money were stolen on your trip. What do you think the others would do?

2. In January 2010, a heavy earthquake occurred in Haiti. Approximately 200,000 people died and many buildings and roads were destroyed. In February, a travel agency offered tours to the disaster area, so tourists could see for themselves how the people in Haiti were rebuilding their facilities. What do you think of this? Do you consider it to be right or wrong that these tours were being offered? Give arguments.
The first prompt is derived from an exercise to elicit written expository output from high school students (TheWritingSite, 2009) (content is given in Appendix F). The second prompt was inspired by Berman and Verhoeven (2002), who used a moral conflict to elicit expository discourse. Participants were asked to answer each question in approximately 200 words, using a computer and word processing software. After 30 minutes, the task was ended by the researcher.

**Analysis of the language samples**

Except for modality-specific procedures concerning segmentation and spelling, the method used to analyse the morphosyntactic correctness and syntactic complexity of the written language samples was identical to the method used to analyse the spoken language samples (Huysmans et al., 2014). The same parameter set was used in both modalities, as the assumption was made that language production in writing and in speech could be evaluated analogously. In both modalities, samples were segmented into utterances, based on the grammatical structure of the output: an utterance was defined as one independent clause with all attached subordinate clauses, which is equal to the definition of a T-unit by Hunt (Hunt, 1970). For the written modality, this implies that segmentation was carried out independently of the writer’s own punctuation.

In line with earlier research (Nippold et al., 2005b; Verhoeven et al., 2002), the **syntactic complexity** of the written utterances was assessed using mean length of utterance in words (MLU), clausal density (i.e., the average number of independent and subordinate clauses per utterance), and the occurrence of three types of subordination as indicators. Subordination use was expressed as the percentage of utterances containing one or more relative clauses (e.g., ‘I forgot the money that we had lost.’), one or more nominal clauses (e.g., ‘I knew that he was there.’), and one or more adverbial clauses (e.g., ‘When you go there, you should help people.’) (Nippold et al., 2005b).

For the analysis of **morphosyntactic correctness**, all morphosyntactic errors that could not be attributed to the violation of an orthographic spelling rule were counted. Errors in spelling (i.e., typing errors or errors in conversion of a phoneme into a grapheme) were disregarded and thus not counted for further analysis. As a general indication of morphosyntactic correctness, the total number of morphosyntactic errors in the written sample was calculated, as well as the number of utterances containing one or more morphosyntactic errors (i.e., number of ungrammatical utterances). Then, all morphosyntactic errors were categorised into fifteen error categories (see Appendix G for examples), analogously to the error categories used in the analysis of spoken language production (Huysmans et al., 2014): (1) subject-verb agreement error in the present tense, (2) past tense inflection error, (3) past participle inflection error, (4) omission of a main verb, (5) omission of an auxiliary or copula verb, (6) omission of a noun phrase (subject or object), (7) word order error, (8) omission of a determiner in an obligatory context, (9)
incorrect determiner\(^4\), (10) suffix error (other than finite verb morphemes), (11) preposition error, (12) pronoun error (personal, demonstrative, reflexive, and relative pronoun), (13) adverb error, (14) conjunction error, (15) other morphosyntactic errors. The error categories either reflected common errors in the acquisition stage, i.e., (1) to (9) (van den Dungen & Verbeek, 1999), or were used in studies on the spoken performance of children and adolescents with CHI, i.e., (10) to (12) (adopted from the study of Elfenbein et al., 1994). Three more variables were added to cover all observed errors, i.e., (13) to (15).

*Calculation of the parameter values*

The writing assignment contained a predefined set of questions and the length of the response to each question was targeted in words. This resulted in variation between participants in the number of utterances of the written sample (further referred to as ‘sample size’). To allow group comparisons, the values of the parameters for morphosyntactic correctness were rescaled to a ratio using sample size (i.e., number of errors / sample size * 100), which is a common procedure in language sample analysis (Scott & Windsor, 2000). The outcomes for syntactic complexity did not need rescaling, as they were, by definition, calculated as ratios relative to the sample size\(^5\).

*Reliability of the analyses*

An experienced clinical linguist reanalysed ten percent of the samples (as in Scott & Windsor, 2000) to examine the reliability of the analyses. Segmentation and analytical judgements of the two coders were compared, yielding a good reliability. The mean percentage agreement for all variables was 98.06%. For the individual variables, the percentage agreement varied from 94.51% to 100%.

\(^4\) In contrast to the method of van den Dungen and Verbeek (1999), errors in adjectival inflection were separated from the category ‘incorrect determiner’ (9) and added to error category (10) (‘other suffix errors than verb morphemes’), because a common cause for these errors cannot be assumed in adult language.

\(^5\) The authors are aware of ongoing discussions concerning the reliability of MLU to identify language impairment in children (see Eisenberg et al, 2001, for a review). The effect of sample size on MLU has been a topic of debate, as well as the unit for counting MLU (i.e., words versus morphemes) (Oosthuizen & Southwood, 2009). The current study, however, does not aim to assess language impairment in individuals, but uses MLU to compare the syntactic complexity of adults’ written samples in a group-based comparison. Given this purpose, MLU is an appropriate choice. Additionally, the use of MLU in words as a measure of syntactic complexity is in line with earlier research (see Nippold et al, 2005a, 2008).
RESULTS

Sample size of the written output

Between subjects in the NH group, the sample size of the written output (i.e., number of utterances in the sample) ranged from 13 to 34 utterances, with a median of 27.0 utterances. In the MSCHI group, the sample size ranged from 14 to 37 utterances, with a median of 28.5 utterances. Because sample size values did not show a normal distribution, a non-parametric test was used to evaluate group differences. This yielded no significant difference in sample size between the NH and MSCHI group \(\text{Mann-Whitney } U = 126.500; \, n_{\text{NH}} = 10, \, n_{\text{MSCHI}} = 20; \, p > 0.05\).

Syntactic complexity of the written output

Figure 1 shows the median score and interquartile intervals for the measures of syntactic complexity of the written output for the NH and MSCHI group. As a reference point, the group data for these measures in the spoken language samples (Huysmans et al., 2014) are added to Figure 1.

![Figure 1: Group scores for the measures of syntactic complexity for the spoken (S) and written (W) modality. Group median, interquartile levels, and 10% and 90% intervals are indicated \(n_{\text{NH}} = 10, \, n_{\text{MSCHI}} = 20\). One group comparison yielding a significant difference is marked \(* p < 0.05\).](image-url)
To examine whether the groups differed in syntactic complexity of the utterances in the written samples, non-parametric group comparisons were done. The outcomes are given in Table 1. No significant group differences were found between the NH and MSCHI group for MLU in words, clausal density, relative clause use, and adverbial clause use. For nominal clause use, a significant difference between groups was found, indicating that relatively more utterances of the NH adults contained a dependent nominal clause.

Table 1. Results of non-parametric tests for group comparisons for all measures of syntactic complexity and morphosyntactic correctness

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group comparison (MSCHI vs. NH)</th>
<th>M-W U</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean length of utterance in words</td>
<td>65.0</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Clausal density</td>
<td>82.0</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>Relative clause use</td>
<td>68.5</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>Adverbial clause use</td>
<td>81.5</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>Nominal clause use</td>
<td>54.5</td>
<td>0.04*</td>
<td></td>
</tr>
<tr>
<td>Ungrammatical utterances</td>
<td>106.0</td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td>Morphosyntactic errors</td>
<td>107.0</td>
<td>0.78</td>
<td></td>
</tr>
<tr>
<td>Omission of a main verb</td>
<td>77.5</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>Subject-verb agreement error</td>
<td>86.5</td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>Omission of an auxiliary of copula verb</td>
<td>120.0</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>Omission of a noun phrase</td>
<td>100.0</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Word order error</td>
<td>104.0</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>Omission of a determiner</td>
<td>118.5</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>Incorrect determiner</td>
<td>121.5</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>Other suffix error</td>
<td>106.0</td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td>Preposition error</td>
<td>121.0</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>Pronoun error</td>
<td>113.5</td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>Adverb error</td>
<td>99.5</td>
<td>0.98</td>
<td></td>
</tr>
<tr>
<td>Conjunction error</td>
<td>87.0</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>Other errors</td>
<td>101.5</td>
<td>0.95</td>
<td></td>
</tr>
</tbody>
</table>

\(n_{NH} = 10, n_{MSCHI} = 20; \text{M-W } \text{U } = \text{Mann-Whitney } U; \text{The one significant difference is marked (Asymptotic Sig. (2-sided test): } ^* p \leq 0.05); \text{MSCHI, moderate to severe congenital hearing impairment; NH, normal hearing.}

To examine the hypothesis that participants’ utterances were syntactically more complex in writing than in speech, the outcomes in the spoken and written modality of two measures of syntactic complexity (MLU in words and clausal density) were compared within groups. Non-parametric Wilcoxon matched pairs tests revealed a greater complexity in writing than in
speech for both measures within both groups (NH: Wilcoxon $Z = 55.000; p < 0.01$ for both MLU and clausal density; MSCHI: Wilcoxon $Z = 208.000; p < 0.01$ for both MLU and clausal density; $n_{NH} = 10$, $n_{MSCHI} = 20$). This finding implies that the morphosyntactic outcome values for the participants’ written output in the following paragraph generally stem from syntactically more complex utterances than the outcomes from their spoken output.

**Morphosyntactic correctness of the written output**

Figure 2 shows the median score and interquartile intervals for the measures of morphosyntactic correctness of the written output for the NH and MSCHI group. Errors on past tense and past participle inflection did not occur in the language samples and are therefore not included in Figure 2. As a reference point, we have added the group data of the morphosyntactic outcome measures of the spoken language samples (Huysmans et al., 2014) to Figure 2.

**Figure 2:** Group scores for the morphosyntactic measures for the spoken (S) and written (W) modality. Group median, interquartile levels, and 10% and 90% intervals are indicated ($n_{NH} = 10$, $n_{MSCHI} = 20$). All error scores were rescaled according to individual sample size (number of errors / number of utterances in the sample * 100). Group comparisons yielding a significant difference are marked (* $p < 0.05$; ** $p < 0.01$).
Chapter 3

Given the nature of the morphosyntactic error measures, with scores close to 0 as most frequently occurring values, the outcomes showed a positively skewed distribution. Therefore, group comparisons were done with non-parametric tests, yielding outcomes as represented in Table 1. For the written data, no group differences were found for any of the morphosyntactic measures.

Effect of level of education on group comparison for number of morphosyntactic errors

To examine whether the level of education, categorised into three categories in line with CBS (2010), had an effect on the group comparison for one of the general morphosyntactic measures (i.e., number of morphosyntactic errors), additional analysis was done. Linear regression analysis using logarithmic transformed values for number of morphosyntactic errors as the dependent variable and group (NH / MSCHI) as determinant confirmed the absence of a significant relation between the two ($R^2 = 0.003; B_1 = 0.109; p = 0.772; N = 30$). When level of education was added into the regression as an extra determinant, this factor did not have a significant effect ($B_1 = 0.267; p = 0.455; N = 30$). Differences between the groups in level of education could thus not explain the absence of a difference between the groups in morphosyntactic correctness in writing.

Associations between written morphosyntactic measures and the degree of CHI

Within the MSCHI group, we examined a possible association between the participants’ degree of CHI (first known PTA$\text{}_{(0.5, 1, 2 \text{ kHz})}$ ranging from 37 to 93 dB HL) and the frequency of morphosyntactic errors in their written samples. Visual inspection of the data in scatter plots showed that the variance in error scores within the MSCHI participants at the lower end of the PTA$\text{}_{(0.5, 1, 2 \text{ kHz})}$ range was comparable to the variance in error scores within the NH group. However, towards the upper end of the PTA$\text{}_{(0.5, 1, 2 \text{ kHz})}$ range, the MSCHI participants’ error rates showed a trend of increasing numbers of errors. This may imply that MSCHI only affects written language performance when the degree of CHI is relatively high. The absence of group differences in error rates may then be caused by the relatively large amount of participants with a lower degree of CHI in the MSCHI study group. Spearman’s rho correlation analysis (see Table 2 for details) showed that the degree of CHI correlated significantly with the two overall morphosyntactic measures (i.e., number of ungrammatical utterances and number of morphosyntactic errors) and with three specific error categories (omission of a determiner, incorrect determiner, and adverb error). This analysis confirmed the visually observed trend: when a participant’s degree of CHI was higher, more errors occurred in the written language sample.
Table 2. Results of non-parametric correlation analysis within the MSCHI group between the measures of morphosyntactic correctness and degree of congenital hearing impairment

<table>
<thead>
<tr>
<th>Variable</th>
<th>Analysis of correlation with degree of CHI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( r_s )</td>
</tr>
<tr>
<td>Ungrammatical utterances</td>
<td>0.53</td>
</tr>
<tr>
<td>Morphosyntactic errors</td>
<td>0.56</td>
</tr>
<tr>
<td>Omission of a main verb</td>
<td>0.15</td>
</tr>
<tr>
<td>Subject-verb agreement error</td>
<td>0.32</td>
</tr>
<tr>
<td>Omission of an auxiliary of copula verb</td>
<td>0.45</td>
</tr>
<tr>
<td>Omission of a noun phrase</td>
<td>0.39</td>
</tr>
<tr>
<td>Word order error</td>
<td>0.39</td>
</tr>
<tr>
<td>Omission of a determiner</td>
<td>0.55</td>
</tr>
<tr>
<td>Incorrect determiner</td>
<td>0.50</td>
</tr>
<tr>
<td>Other suffix error</td>
<td>0.42</td>
</tr>
<tr>
<td>Preposition error</td>
<td>0.39</td>
</tr>
<tr>
<td>Pronoun error</td>
<td>0.36</td>
</tr>
<tr>
<td>Adverb error</td>
<td>0.59</td>
</tr>
<tr>
<td>Conjunction error</td>
<td>0.38</td>
</tr>
<tr>
<td>Other errors</td>
<td>-0.14</td>
</tr>
</tbody>
</table>

\( n_{MSCHI} = 20; r_s = \text{Spearman's rho correlation coefficient}; \text{Significant differences are marked (Asymptotic Sig. (2-sided test): }^* p \leq 0.05, **p \leq 0.01); \text{MSCHI, moderate to severe congenital hearing impairment} \)

**DISCUSSION**

This study evaluated the performance of adults with moderate to severe congenital hearing impairment (MSCHI) in written language production and examined whether morphosyntactic correctness of written language production was associated with the degree of CHI within the MSCHI group. At the group level, our results showed that problems with morphosyntactic correctness that were observed in the spoken output of the MSCHI adults (Huysmans et al., 2014) did not occur in their writing: using the same outcome parameters as in the analysis of the spoken samples, no group differences were found between adults with MSCHI and adults with normal hearing (NH) in the morphosyntactic correctness of their written output. Within the MSCHI group, the occurrence of specific errors in the written output was associated with the severity of the adults’ hearing impairment at a young age (degree of CHI). This association may imply that long-term effects of CHI on written language production are only evident in adults with more severe auditory limitations in childhood.

We explored several possible explanations for the absence of a difference between the MSCHI and NH group in morphosyntactic correctness of the written output. First, we performed a
group-wise comparison of the measures of syntactic complexity of the written language samples. If the groups differed in this aspect, this would interfere with the group comparison of morphosyntactic correctness, as syntactic complexity is assumed to influence the likelihood for morphosyntactic errors to occur. Analysis showed that the groups did not differ in syntactic complexity of the written language samples, except for the use of nominal subordinate clauses. In general, the absence of a group difference in morphosyntactic correctness of the written output could thus not be attributed to a group difference in syntactic complexity. The finding that NH adults used more nominal clauses in their writing than the adults in the MSCHI group is difficult to interpret. In the course of spoken language development, more frequent use of nominal subordinate clauses indicates a lower level of syntactic attainment (Scott & Windsor, 2000), but little is known about how this finding should be interpreted when assessing syntactic complexity in writing in mature language users. Second, as written language production is established following instruction in an educational context, the generally higher level of education of the MSCHI adults compared to the adults in the NH group could explain the absence of group differences in writing. However, analysis of our data showed that this was not the case. Differences between groups in distribution of level of education of the participants did not explain the absence of group differences in morphosyntactic correctness. Third, visual inspection of our data showed that the variance in the error rates within the NH group was comparable to the variance in error rates between the MSCHI participants with a relatively favorable degree of CHI, as expressed with their first known PTA. In contrast, adults with a higher degree of CHI appeared to show higher error rates. This visually observed trend was confirmed by a significant correlation between the degree of CHI and several morphosyntactic error measures. The absence of a group difference in error rates between the NH and MSCHI group may thus be caused by the relatively large amount of participants with a lower degree of CHI in the MSCHI study group.

The association between the degree of CHI and the morphosyntactic correctness in writing suggests that long-term effects of CHI on written language production could only be expected in adults with a higher degree of CHI. Results of studies in adults with a more severe degree of CHI than the adults in the current study support this prediction (Fabbretti et al., 1998; van Beijsterveldt & van Hell, 2010; Vollmann et al., 2002). Furthermore, the relation we found between the degree of CHI and morphosyntactic correctness of language production in both modalities is in line with the inconsistent access account (Moeller & Tomblin, 2015): more limited access to linguistic input during language acquisition is predicted to result in more pronounced effects on linguistic abilities.

When comparing the performance of the two groups in this study for their spoken and written language production, it is striking that the groups differed in morphosyntactic correctness of their spoken output while this group difference was not found in the written modality. Before discussing differences in processing between modalities that could explain this performance pattern, we first address the issue of how both groups performed in each modality. For the
Written language production

morphosyntactic parameters in which a group difference was found in the spoken modality, the question arises whether the absence of group differences in the written modality is accounted for by better performance of the MSCHI group in writing than in speech, or by poorer performance of the NH group. When examining the morphosyntactic data in Figure 2, we noticed that subject-verb agreement errors occurred relatively frequently in the written samples of the NH adults, while these occurred less frequently in their spoken language. This may imply that no group difference was found for this category in the written modality because the adults of the NH group made more errors in their writing. A more detailed inspection of the type of errors within this category showed that the NH adults mainly made errors in verb agreement with a compound subject (e.g., ‘als mijn geld en paspoort *is gestolen’ ‘if my money and passport *is stolen’ (3SG instead of 3PL)) and so-called ‘attraction errors’ (Zandvoort, 1961) (e.g., ‘als een groep toeristen daarheen *gaan om te helpen’ ‘if a group of tourists *go there to help’ (3PL agreement with ‘tourists’ instead of 3SG agreement with ‘group’)). In the written samples of the MSCHI adults, other types of subject-verb agreement errors appeared that did not occur in the samples of the NH adults (e.g., ‘Wat ook erg handig is, is dat Paul goed Frans en Spaans *spreek’ ‘What is really handy as well, is that Paul *speak French and Spanish well’). This specific error type, i.e., omission of the inflectional suffix, was also observed in the spoken language production of the MSCHI adults. This observation in written language production may indicate that the currently used scope of this error category possibly conceals actual differences between the MSCHI and NH adults in their performance in the written modality. Future research including more specific analysis of different error types within this category could examine this hypothesis. For the categories ‘adverb error’ and ‘omission of a determiner’, the data did not yield any leads to explain why group differences were found in the spoken modality, but not in the written modality. Hence, we will now discuss processing differences between the two modalities that could account for this performance pattern.

For the MSCHI participants in this study, variability in their performance in spoken language production was discussed in view of the vulnerable marker hypothesis (Bishop, 1994; Huysmans et al., 2014). In a task condition in which the language production system was strained, the MSCHI adults made errors in the application of specific morphosyntactic markers. The current data showed that CHI-induced weaknesses in the use of specific markers while producing spoken language did not surface in the written modality. Given the differences in language production processing between the modalities, this may be associated with less strain on the language production system in the writing task than in the task we used for eliciting spoken language. Though the written samples showed greater syntactic complexity than the spoken samples in both groups, which was expected to increase the strain on the written language production system, this did not affect the correctness in writing. The vulnerable marker hypothesis thus does not seem to apply to the writing task as used in this study: as writing has lower time constraints than spoken language production and explicit knowledge may be consulted...
during cycles of revision, the observed difference in performance between modalities may be determined by these processing characteristics. In future research, a writing task with more restricting time constraints could be more sensitive to examine possible weaknesses in the writing performance of MSCHI adults. Next to this, the use of software that registers all actions of writing and revising (e.g., Lindgren & Sullivan, 2002) could yield additional insights in the processes that lead to the written output as analysed in this study.

In a clinical context, the findings of this study indicate that clinicians should be conscious of possible weaknesses in the linguistic abilities of adults with CHI that are not apparent in all contexts. When the language production system is strained, vulnerabilities in the use of specific morphosyntactic markers may surface, thereby possibly affecting the interaction. Furthermore, in patients who were born with a considerable severity of hearing loss, it is more likely that morphosyntactic weaknesses occur in their language production.

**CONCLUSION**

Our results showed that, at the group level, problems with morphosyntactic correctness that were observed in the spoken output of the MSCHI adults (Huysmans et al., 2014) did not occur in their writing. The observed difficulties in the spoken performance of the MSCHI adults were hypothesised to reflect a MSCHI-induced vulnerability in the use of specific morphosyntactic markers that are low in perceptual salience or relatively high in grammatical complexity. This vulnerability resulted in performance problems when the language production system was strained. Data of the current study showed that the observed vulnerabilities in spoken language production did not surface in written language production. Given the differences between the modalities in language production processing, it was discussed to be likely that the lower demands of the written task put less strain on the language production system. As a result, MSCHI-induced vulnerabilities in the use of morphosyntax did not surface in writing like in speech. However, within the MSCHI group, morphosyntactic correctness of the written output in adulthood was associated with the degree of auditory limitations in the period of spoken language acquisition. At the individual level, this may imply that long-term effects of MSCHI on written language performance may be evident in adults with a more severe degree of CHI.