Phonological and grammatical production in children with developmental language disorder
and children with hearing impairment.

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Abstract

Children with hearing impairment (HI) are at an increased risk of developing speech and language problems similar to those of children with developmental language disorder (DLD), including difficulties with phonology and grammar. This study investigated similarities and differences in phonological and grammatical production between children with bilateral sensorineural HI (n=14) and children with DLD (n=30) between 4-6 years of age and age-matched controls with typical language development and normal hearing (TLD) (n=29), all with Swedish as their first language. Production of consonants, vowels, stress patterns and tonal word accents was assessed in a picture naming task, and in a word and nonword repetition task. Grammatical production was assessed for verb and noun morphology, and syntax. While performance for both children with HI and DLD were generally significantly below that of the controls with TLD, production of accents and syntax emerged as relative strengths. There were few differences between the children with HI and DLD, but noun–adjective agreement in predicative was more challenging for the children with HI. The results have implications for language assessment and planning of intervention.

I Introduction

Problems with phonology, morphology and syntax are common in children with developmental language disorder (DLD)¹ or hearing impairment (HI) (Cleary, 2009; Schwartz, 2009). The fact that these populations develop language in different conditions—with and without normal hearing—but display partly similar language difficulties, warrant investigations of how they differ from each other. It can also be assumed that a subgroup of children with HI, at least 7% (Tomblin et al., 1997), would have a language disorder independent of their hearing loss, although recent studies suggest that language problems are prevalent in as much as 50% of children with mild–moderate HI (Delage and Tuller, 2007). Recent studies suggest that children with HI wearing cochlear implants (CI) may experience greater deficits in phonological compared to morpho-syntactical ability, due to the higher demands on phonetic detail required (Nittrouer et al., 2014; Nittrouer et al., 2016).

Nonword repetition (NWR), i.e. repetition of word-like forms without meaning, is a complex task, involving hearing, working memory, speech perception and production (Coady and Evans, 2008). NWR has been identified as an indicator of language difficulties in children with specific language impairment (Dollaghan and Campbell, 1998), children with HI using cochlear implants (Nittrouer et al., 2014), and has also been found difficult for children with mild–moderate HI using hearing aids (Halliday et al., 2017). Given the potential usefulness of NWR as a diagnostic tool, detailed studies of repetition performance, and how it relates to different aspects of language ability, are motivated. Swedish-speaking children with DLD or HI exhibit problems with repetition of both segmental and prosodic features of nonwords (Ibertsson et al., 2008). There is also some evidence to support association of NWR to

¹ Following the recent debate on terminology for children who have persisting language difficulties, the term developmental language disorder (Bishop et al., 2017) is used here, and is considered more or less equivalent to e.g. 'language impairment', 'specific language impairment' or 'primary language impairment'.

expressive phonology and grammar in Swedish-speaking children with DLD (Sahlén et al., 1999), and HI (Sundström et al., 2018).

The Swedish phoneme system has nine vowels, each with one short and one long realization, and 18 consonants (Riad, 2014). Production and contrastive use of the consonants /p/, /t/, /k/, /m/, /n/, /v/, /j/ and, /h/, and the vowels /a/, /ɑ:/, /ɛ:/, /u:/, /o:/, typically develops before the age of four, and all phonemes except /r/, /ʁ/, and /ɸ/ are established before six years of age (Nettelbladt, 2007). Swedish has variable lexical stress between words, and a system with two tonal word accents. The tonal word accents are realized as distinct pitch patterns aligned with the stressed syllable of the word, and all stressed words have either tonal word accent 1 or 2. Monosyllables and words with final stress have tonal word accent 1, while tonal word accent 2 requires an unstressed syllable after the stress (Bruce, 2012). The trochee is the predominant foot, i.e. syllables are arranged in a strong–weak pattern, and this is also the pattern preferred by children in the early stages of development. Tonal word accent 2 is typically developed before tonal word accent 1, and contrastive use of the tonal word accents is established around the age of four (Peters and Strömqvist, 1996).

In typical Swedish grammatical development genitive -s is one of the first suffixes to appear, and approximately 80% of typically developing children use s-suffixation of nouns at 28 months of age (Berglund and Eriksson, 2000). Plural form suffixes also develop early.

Definite form suffixes surface somewhat later, but precede the use of indefinite articles. Verb inflections tend to come somewhat later than inflection of nouns, and infinitives are typically used first, followed by present tense, supine forms, and preterite past tense (Håkansson and Hansson, 2007). Compound tenses expressing future and present perfect are developed later,

and about 50% of children produce these forms at 28 months of age (Berglund and Eriksson, 2000).

Both free and bound grammatical morphemes in Swedish usually comprise unstressed syllables, which may present a challenge to children with DLD or HI due to short duration and low perceptual saliency (Leonard et al., 1997; Svirsky et al., 2002). Acquisition and use of these morphemes might also be constrained by the fact that they frequently occur in prosodic positions before the stress, outside the predominant trochaic stress pattern (Gerken, 1994; Hansson et al., 2003). The tonal word accent system is also related to morphology in that the assignment of tonal word accent 1 or 2 is predictable based on morphological factors (Bruce, 1977). For example, the stem *lek*– in combination with the present tense suffix –er forms the tonal word accent 1 word *léker* ‘play/plays’, but together with the infinitive suffix –a the result is the tonal word accent 2 word *lèka* ‘[to] play’.

5 Study aims

The aim of the present study was to explore similarities and differences between children with DLD, children with HI, and children with TLD, on phonological, including prosodic, and grammatical production. Children with DLD or HI are at an increased risk of both phonological and grammatical impairment. Children with DLD are expected to perform on a level below that of age-matched peers with TLD and normal hearing, as this is inherent in the condition. Children with HI can also be expected to achieve results that are, on average, below that of the TLD children, although the difference may be greater for phonological compared to grammatical production (Nitttrouer et al., 2014; Nitttrouer et al., 2016).

II Method

1 Participants

Three groups of children aged 4–6 years were included in the present study: children with DLD, children with HI, and children with TLD. Following ethical approval from the Regional Ethical Review Board in Linköping, Sweden (Dnr 2013/92-31), caregivers of all participants received written information about the study through speech-language or audiology clinics, or through preschools. They were also given the opportunity to further inquire about the study before deciding to let their children participate. The children were given simplified oral information prior to testing. To be eligible for inclusion, all children should be aged between 4 and 6 years, and use spoken Swedish, with a Central Swedish dialect, as their primary language. Further, the children could not have any known neurodevelopmental or psychiatric disorders. As part of a brief parental interview, information was collected about parental education, the children's use of hearing aids and cochlear implants, history of hearing deficits and educational setting. Nonverbal intelligence was assessed with the block design subtest of the Wechsler Preschool and Primary Scale of Intelligence, Third Edition (WPPSI–III) (Wechsler, 2005).

The group of children with DLD comprised 30 children, whereof 10 were boys and 20 girls. They ranged in age from 49 to 74 months ($M = 59.3$, $SD = 7.3$). The specific inclusion criteria for the DLD group were that the children should have a confirmed diagnosis of developmental language disorder/language impairment, previously assessed by a clinical speech and language therapist (SLT). Their language deficits should be mainly phonological and/or grammatical, excluding pronounced lexical, semantic and pragmatic deficits. The

children also had to be normally hearing from birth, without any history of hearing deficits, e.g. because of repeated otitis media with effusion, as reported by their caregivers.

The group of children with HI consisted of 14 children, 11 girls and three boys, aged between 48 and 80 months ($M = 60.3$, $SD = 9.8$). Criteria for inclusion specific to this group of children were bilateral congenital sensorineural hearing impairment, and full time use of hearing aids or cochlear implants. Their degree of hearing impairment ranged from mild to profound (Clark, 1981). Nine children used conventional hearing aids on both ears, two children used both a cochlear implant and a hearing aid, and three children used bilateral cochlear implants. The median age at implantation of the first CI was 15 months (range 9.6–49.2), and the median age at first HA fitting was 29 months (range 3.0–55.9). Cause of hearing impairment was unknown for 12 of the children, inner ear malformation for one child, and suspected but not confirmed congenital cytomegalovirus (CMV) infection for one child. All children were raised in hearing, Swedish-speaking families, and attended preschool integrated in a mainstream educational setting. None of the children used sign language.

In the group of children with TLD, 29 children (18 girls and 11 boys) participated. They were between 49 and 80 months old ($M = 61.3$, $SD = 8.2$), and came from the same geographical areas as the children with DLD or HI. The children with TLD could not have a diagnosed disorder of language or cognition, and should have normal hearing, without any history of hearing deficits, as reported by their caregivers.

2 Procedures

All children were tested by a SLT, in a quiet room, either at a hospital clinic, at home, or at the preschool. Total time of testing was about 90–120 minutes, including suitable breaks. If needed, the testing could be performed on separate days. All tests were administered in a randomised order.

a Phonological production

The children's ability to repeat segmental and prosodic lexical features were assessed in a picture naming task and in a word repetition (WR) and nonword repetition (NWR) task. The measures obtained were percentages of correctly produced consonants, vowels, stress patterns, and tonal word accents.

The short version of the Phoneme Test (Hellqvist, 1995) was used to assess phonological production when naming known words. The test includes 72 pictures corresponding to child-appropriate words that give an overview of the child's phoneme inventory. Most Swedish phonemes and the most common consonant clusters are represented in different word positions. The targets as intended are 32 monosyllabic words, 32 disyllabic words, seven three-syllable words, and one five-syllable word. There is a variation in stress patterns, but penultimate stress is the most frequent in the word with more than one syllable. All monosyllables have tonal word accent 1, and out of the multisyllabic words, 13 have tonal word accent 1, and 27 have tonal word accent 2. All child productions were accepted, even when they differed lexically from the words originally intended (e.g. saying *handfat* 'sink' instead of *kran* 'tap'). Words that the children did not attempt to produce were excluded from the analyses. All responses were audiorecorded and transcribed phonetically.

Phonological production during repetition was examined using a WR and NWR task (Sundström et al., 2014). Twenty-five one- to five-syllable words and nonwords, matched pairwise for stress and tonal word accent were included. As far as possible, words have been chosen that are familiar to children, but no procedure was undertaken to ensure that the children did in fact know the words included. The task is designed to include all possible stress patterns, and for stress patterns that allow for either tonal word accent 1 or 2 (i.e. items with more than one syllable and non-final stress), there is one word/nonword with tonal word accent 1 and one with tonal word accent 2. Stimuli were pre-recorded and presented at approximately 70 dB SPL. The children repeated either the words or the nonwords first, and were instructed to repeat them as well as they could. All responses were audiorecorded and transcribed phonetically. Non-responses were not included for further analysis.

b Grammatical production

Gramba (Hansson and Nettelbladt, 2004) was used for the assessment of grammatical production. In this test, Swedish verb morphology, nominal morphology, and syntax are targeted using sentence continuation and completion. For the purpose of the present study, 14 different subcomponents were analysed, which are described in table 1.

Table 1. Description of the Gramba grammatical production test.

	<i>Max score</i>	<i>Targeted structures</i>	<i>Example</i>	<i>Translation</i>
Verb morphology				
Present tense	3	Verb stem + suffix (-er)	köp-er	buys
Past tense preterite	3	Verb stem + suffix (-te)	köp-te	bought
Future tense	3	Auxiliary verb + infinite verb	ska köpa	will buy
Past tense perfect	3	Auxiliary verb + supine verb	har köpt	has bought
Copula	3	Copula verb	är	is
Nominal morphology				
Plural	3	Noun stem + suffix (-ar/-er/-or)	katt-er	cats
Indefinite article	3	Article (en/ett) + noun	en katt	a cat
Definite form	3	Noun stem + suffix (-en/-et)	katt-en	the cat
Noun phrase agreement	4	Article + adjective + noun	den stora katten	the big cat
Genitive case	3	Noun stem + definite form suffix + genitive suffix (-s)	katt-en-s	the cat's
Adjective predicative agreement	3	Subject + copula + adjective	katten är gul	the cat is yellow
Syntax				
Negation placement	3	Auxiliary verb + negation + infinite verb	kan inte hoppa	cannot jump
Relative clause	3	Relative pronoun + verb	som äter	who eats
Topicalization	4	Topicalized word + verb + subject	sen sover de	then they sleep
Total max score	44			

3 Data analysis

Based on transcriptions, percentages of correctly produced consonants (PCC), vowels (PVC), stress patterns, and tonal word accents were calculated for the Phoneme Test and the WR and NWR task. The formula used was *(the number of correct productions/(the number of correct + incorrect productions))*. Allophonic variants of phonemes were accepted (e.g. [ɹ] instead of [r]), as were minor non-phonemic articulatory deviations (e.g. [ʂ] instead of [s]).

Nonparametric Kruskal-Wallis tests were used to compare the groups (DLD, HI, TLD) on each of the phonological and grammatical measures, as well as on age, nonverbal intelligence, and maternal education. Significant main effects were followed up using pairwise comparisons with adjusted *p*-values, with the overall *α*-level set to 0.05. For the pairwise comparisons, *r* was used as an estimate of effect size; values above 0.10, 0.30, and 0.50 correspond to small, medium, and large effects, respectively (Cohen, 1992).

4 Inter-rater reliability

Ten percent of the recordings from the phonological production tasks were transcribed by an experienced SLT to enable assessment of inter-rater reliability. Point-by-point agreement between the transcribers was calculated using the formula $(\text{number of agreements}) / (\text{number of agreements} + \text{disagreements}) \times 100$. Total agreement was 90.3% for segments (consonants and vowels combined), 97.4% for tonal word accents, and 97.1% for stress.

III Results

No difference between the three groups were found for age or nonverbal intelligence, while there was an overall group difference with respect to maternal education ($H(2) = 6.12, p = 0.047$). Mothers of the children with TLD had significantly more years of education, $M = 16.0, SD = 2.3$, compared to mothers of the children with HI, $M = 14.0, SD = 2.1$ ($p = 0.044, r = 0.29$). There were no differences between the children with TLD and DLD, or between children with DLD and HI.

1 Phonological production

Phonological production was assessed in three conditions: a naming task where the child used familiar words, as well as WR and NWR. The overall results on the phonological production tasks are displayed in figure 1.

Figure 1. Results on the phonological production tasks.

a Naming

Results and Kruskal-Wallis group comparisons the Phoneme test are shown in table 2. There was a significant effect of group on the production of consonants. Pairwise comparisons revealed that the TLD group outperformed both the children with DLD ($p < 0.001$, $r = 0.72$), and the children with HI ($p = 0.002$, $r = 0.40$). No difference was found between the DLD and HI groups. A significant effect of group was also found for vowel production. The relative performance was the same as for consonants, with the TLD group achieving higher scores than both children with DLD ($p < 0.001$, $r = 0.60$) and HI ($p = 0.001$, $r = 0.41$), while no difference was found between the latter two groups.

The groups differed significantly on the production of stress patterns. Pairwise comparisons indicated that the higher results for the TLD group compared to the children with DLD ($p < 0.001$, $r = 0.48$), and HI ($p < 0.001$, $r = 0.34$). No difference was found between the groups with DLD and HI. The ability to produce tonal word accents also differed between the groups. Children with TLD scored higher than the children with DLD ($p = 0.006$, $r = 0.36$), but no other significant differences were found.

Table 2. Descriptive statistics and group comparisons for the Phoneme test.

	DLD			HI			TLD			$H(2)$	p
	M	SD	95% CI	M	SD	95% CI	M	SD	95% CI		
PCC	70.4	11.6	66.1, 74.8	74.2	23.5	60.6, 87.7	93.0	6.6	90.4, 95.5	38.84	< 0.001
PVC	89.1	4.8	87.3, 90.9	88.0	11.0	81.6, 94.3	96.3	2.7	95.3, 97.4	28.82	< 0.001
Stress	94.7	3.8	93.3, 96.2	93.9	6.9	90.0, 97.9	98.2	1.9	97.5, 98.9	18.69	< 0.001
Accent	93.5	4.9	91.7, 95.4	94.2	6.3	90.5, 97.8	96.1	5.7	94.0, 98.3	9.64	0.008

Notes. All results are expressed as percentages. WR = word repetition; NWR = nonword repetition;

PCC = percentage of consonants correct; PVC = percentage of vowels correct;

Accent = tonal word accent; DLD = developmental language disorder; HI = hearing impairment;

TLD = typical language development; M = Mean; SD = standard deviation;

95% CI = confidence interval; $H(2)$ = Kruskal–Wallis test statistic(degrees of freedom);

p = probability value.

b Repetition of words and nonwords

Table 3 shows group results and Kruskal–Wallis statistics for the WR and NWR task. The ability to repeat consonants, vowels, stress, and tonal word accent differed significantly between the groups in both words and nonwords, with large effect sizes throughout. Follow-up pairwise comparisons almost consistently revealed the same pattern: The children with DLD and the children with HI displayed lower performance than the TLD group, but they did not differ from each other. However, repetition of tonal word accents in words was lower in the HI group compared to the TLD and DLD groups, who in turn did not differ from each other. It is worth noting that the scores of the HI group were arguably lower compared to the DLD group on most of the repetition measures. Table 4 shows all pairwise comparisons for all WR and NWR measures.

Table 3. Descriptive statistics and group comparisons for the WR and NWR measures.

	DLD			HI			TLD			<i>H</i> (2)	<i>p</i>
	<i>M</i>	<i>SD</i>	95% <i>CI</i>	<i>M</i>	<i>SD</i>	95% <i>CI</i>	<i>M</i>	<i>SD</i>	95% <i>CI</i>		
WR PCC	56.5	11.4	52.2, 60.8	57.8	22.9	44.7, 71.1	82.8	11.6	78.3, 87.2	33.99	< 0.001
WR PVC	76.5	8.2	73.4, 79.5	70.0	19.2	59.0, 81.1	88.7	6.2	86.3, 91.0	30.35	< 0.001
WR Stress	72.1	14.2	66.9, 77.4	61.7	24.5	47.6, 75.9	87.8	8.7	84.5, 91.1	27.06	< 0.001
WR Accent	88.7	10.5	84.8, 92.6	80.7	15.5	71.7, 89.6	93.6	5.1	91.7, 95.6	15.59	< 0.001
NWR PCC	47.9	12.4	43.3, 52.6	46.8	21.6	34.3, 59.2	73.0	13.6	67.8, 78.2	30.79	< 0.001
NWR PVC	74.3	9.8	70.6, 77.9	64.4	19.9	52.9, 75.9	85.2	6.2	82.8, 87.5	23.89	< 0.001
NWR Stress	70.8	15.7	65.1, 76.8	58.3	23.3	44.9, 71.7	84.4	8.5	81.2, 87.7	20.68	< 0.001
NWR Accent	84.9	7.5	82.1, 87.7	76.4	14.6	68.0, 84.8	92.0	5.5	89.9, 94.1	22.69	< 0.001

Notes. All results are expressed as percentages. WR = word repetition; NWR = nonword repetition;

PCC = percentage of consonants correct; PVC = percentage of vowels correct;

Accent = tonal word accent; DLD = developmental language disorder; HI = hearing impairment;

TLD = typical language development; *M* = Mean; *SD* = standard deviation;

95% *CI* = confidence interval; *H*(2) = Kruskal–Wallis test statistic(degrees of freedom);

p = probability value; ns = nonsignificant.

Table 4. Pairwise comparisons for the WR and NWR measures.

	TLD vs. DLD		TLD vs. HI		DLD vs. HI	
	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>
WR PCC	< 0.001	0.66	0.001	0.43	ns	0.05
WR PVC	< 0.001	0.58	< 0.001	0.50	ns	0.03
WR Stress	< 0.001	0.50	< 0.001	0.52	ns	0.11
WR Accent	ns	0.22	< 0.001	0.46	0.046	0.28
NWR PCC	< 0.001	0.60	< 0.001	0.47	ns	0.02
NWR PVC	< 0.001	0.46	< 0.001	0.50	ns	0.13
NWR Stress	0.002	0.40	< 0.001	0.50	ns	0.18
NWR Accent	0.001	0.42	< 0.001	0.50	ns	0.17

Notes. WR = word repetition; NWR = nonword repetition; PCC = percentage of consonants correct; PVC =

percentage of vowels correct; Accent = tonal word accent TLD = typical language development; DLD =

developmental language disorder; HI = hearing impairment; *p* = probability value; *r* = effect size;

ns = nonsignificant.

2 Grammatical production

The effect of group on total grammatical production score was significant ($H(2) = 25.38$, $p < 0.001$). Detailed results on the grammar test are presented below, with a section each for verbal, nominal, and syntactic subtasks. Table 5 displays group scores for each of the subtasks, together with Kruskal–Wallis comparisons. The subsequent follow-up pairwise comparisons, for subtasks where a main effect of group was found, are displayed in table 6.

Table 5. Descriptive statistics and group comparisons for the grammatical production test.

		DLD			HI			TLD				
Verbal	Max	<i>M</i>	<i>SD</i>	95% <i>CI</i>	<i>M</i>	<i>SD</i>	95% <i>CI</i>	<i>M</i>	<i>SD</i>	95% <i>CI</i>	<i>H</i> (2)	<i>p</i>
Present tense	3	2.4	0.8	2.1, 2.7	2.1	0.7	1.8, 2.5	2.7	0.5	2.5, 2.8	5.94	ns
Past tense preterite	3	1.1	1.2	0.7, 1.6	1.1	1.2	0.4, 1.9	2.3	0.8	2.0, 2.6	16.32	< 0.001
Future tense	3	1.5	0.9	1.2, 1.8	1.3	1.1	0.7, 1.9	1.9	0.9	1.5, 2.2	3.55	ns
Past tense perfect	3	1.3	1.0	0.9, 1.7	1.1	1.0	0.5, 1.6	2.1	1.0	1.7, 2.5	12.18	0.002
Copula	3	2.4	0.8	2.1, 2.7	2.0	1.0	1.4, 2.6	2.8	0.4	2.7, 3.0	11.39	0.003
Nominal												
Plural	3	2.4	0.9	2.1, 2.7	2.3	0.9	1.8, 2.8	2.6	0.5	2.4, 2.8	0.71	ns
Indefinite article	3	1.5	0.9	1.1, 1.8	1.0	0.8	0.5, 1.5	2.1	1.0	1.7, 2.5	13.59	0.001
Definite form	3	2.0	1.0	1.6, 2.4	1.2	1.1	0.6, 1.9	2.7	0.6	2.5, 2.9	19.10	< 0.001
Noun phrase agreement	4	1.1	1.3	0.7, 1.6	0.5	0.8	0.1, 0.9	1.6	1.1	1.2, 2.0	9.31	0.010
Predicative agreement	3	2.4	0.9	2.1, 2.7	1.6	0.9	1.0, 2.1	3.0	0.2	2.9, 3.0	29.30	< 0.001
Genitive case	3	2.1	1.0	1.8, 2.5	1.6	1.2	0.9, 2.3	2.6	0.6	2.3, 2.8	7.50	0.024
Syntax												
Negation placement	3	1.9	1.0	1.5, 2.2	2.3	0.9	1.8, 2.8	2.3	1.0	2.0, 2.7	4.30	ns
Relative clause	3	2.6	0.8	2.3, 2.9	2.5	0.9	2.0, 3.0	3.0	0.2	2.9, 3.0	6.22	0.045
Topicalization	4	3.1	1.3	2.6, 3.5	2.7	1.4	1.9, 3.5	2.6	1.5	2.0, 3.2	1.23	ns

Notes. DLD = developmental language disorder; HI = hearing impairment; TLD = typical language development;

Max = maximum score; *M* = Mean; *SD* = standard deviation; 95% *CI* = confidence interval;

H(2) = Kruskal–Wallis test statistic(degrees of freedom); *p* = probability value; ns = nonsignificant.

Table 6. Pairwise comparisons for subtasks of the grammatical production test.

	TLD vs. DLD		TLD vs. HI		DLD vs. HI	
	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>
Verbal						
Past tense preterite	< 0.001	0.43	0.009	0.35	ns	0.00
Past tense perfect	0.011	0.34	0.010	0.35	ns	0.07
Copula	ns	0.25	0.004	0.38	ns	0.18
Nominal						
Indefinite article	0.032	0.30	0.002	0.41	ns	0.17
Definite form	0.022	0.31	< 0.001	0.50	ns	0.25
Noun phrase agreement	ns	0.21	0.008	0.35	ns	0.19
Predicative agreement	0.025	0.31	< 0.001	0.63	0.003	0.39
Genitive case	ns	0.18	0.021	0.32	ns	0.17
Syntax						
Relative clause	ns	0.24	ns	0.25	ns	0.06

Notes. TLD = typical language development; DLD = developmental language disorder;

HI = hearing impairment; *p* = probability value; *r* = effect size; ns = nonsignificant.

Only subtasks with significant main effects of group according to the Kruskal–Wallis tests are included.

a Verbal morphology

No significant differences between the groups were found for present tense inflection (stem–er) or construction of the future tense (ska ‘will’ + infinitive verb). For the ability to produce past tense preterite (stem–te), past tense perfect (har ‘has’ + stem–t), and copula (är ‘is’), there was a significant effect of group (see table 5). Pairwise comparisons (table 6) yielded the

same relations between the groups for all of these variables; the TLD control group performed higher than the DLD and HI groups, who in turn did not differ significantly from each other.

b Nominal morphology

Plural inflection (noun–ar/–er/–or) did not differ significantly between the groups, while there was a significant effect of group on production of indefinite articles (en/ett ‘a/an’), definite form (stem–en/–n/–t ‘the’), noun phrase agreement (article + adjective + noun), predicative agreement (subject + copula + adjective), and genitive case (noun–s) (see table 5). For indefinite articles and definite forms, pairwise comparisons (table 6) revealed that the children with TLD achieved higher scores than the children with DLD and HI, but there was no difference between the two latter groups. Agreement in noun phrases and use of genitive was more challenging for the children with HI compared to children with TLD, but not compared to children with DLD. No difference was found between the children with DLD and TLD. Correct predicative agreement was higher for the children with TLD compared to the groups with DLD and HI. The children with DLD also performed above the children with HI on this task.

c Syntax

The groups did not differ from one another in the syntax subtasks negation placement (auxiliary verb + inte ‘not’ + verb) or topicalization word order (topicalized word + verb + subject). For relative clauses (som ‘who/that’ + verb), there was a significant difference as indicated by the Kruskal-Wallis test. However, the subsequent pairwise comparisons failed to detect any significant differences.

IV Discussion

The children with DLD or HI achieved equal results on all aspects of the naming task, but were generally below the controls with TLD, who performed near ceiling on all measures. Performance in all three groups was quite high for both production of vowels, stress patterns, and tonal word accents. For tonal word accent production, there were no significant differences between the groups. Tonal word accent is realized over the whole word, but needs to be aligned with the stressed syllable. The correct tonal word accent can, however, be realized correctly even if a word is stressed on the wrong syllable. The largest differences between the clinical groups and the controls was found for consonant production, both in naming and repetition of words and nonwords. Consonants in general have less acoustic energy and shorter duration than vowels, features that might pose problems for children with DLD or HI (Leonard et al., 1997; Svirsky et al., 2002).

The pattern of results was consistent for both the WR and NWR tasks: phonological production did not differ significantly between the children with DLD or HI, but the performance of both groups was lower than that of the children with TLD. This relation between the groups was the same regardless of whether the stimuli to be repeated were familiar (words) or unfamiliar (nonwords). The only exception was that the children with DLD repeated tonal word accents in words with the same accuracy as the controls, unlike children with HI who did not do this to the same degree. Like in the picture naming task, tonal word accent scores were relatively high. Consonants, on the other hand, proved to be very difficult to repeat for both the DLD group and the HI group (less than 60% correct in words and less than 50% in nonwords for both clinical groups). There was a trend for vowel, stress,

and tonal word accent repetition to be lower in the HI group than in the DLD group, but no significant differences were found due to the small sample sizes and large variability, especially among the children with HI.

Although lower performance, compared to the control group, children with DLD and children with HI were equal on the production of indefinite articles (e.g. *ett äpple* ‘an apple’; *en katt* ‘a cat’) and definite form suffixes (*äpple-t* ‘the apple’; *katt-en* ‘the cat’). These tasks require the correct use of articles (*en/ett* ‘a/an’) and endings (*-en* or *-n/-et*) with respect to gender.

Indefinite articles comprise unstressed syllables that occur in pretonic positions, i.e. before the stress of the upcoming noun, outside of the predominant strong–weak pattern of Swedish, making them hard to perceive and produce (Gerken, 1994). The definite form suffixes also constitute unstressed syllables, but in the target forms of Gramba they are in a position immediately after the stressed syllable, inside of a strong–weak prosodic structure. Thus, definite form could be regarded as easier than articles, and they also develop earlier.

However, it could not be concluded from the results of the present study that there was a difference between these grammatical elements for either children with DLD or HI.

Noun phrase agreement was the overall most challenging grammar task for all three groups. The children with HI and DLD achieved similar results on this task, but performed below the children with TLD. The task requires the child to produce phrases ranging from three to five syllables, where all elements are in agreement. Also, agreement is expressed partly through articles and suffixes that occur in perceptually disadvantaged positions, e.g. in *det gula äpplet* ‘the yellow apple’ /det gʊla ɛplet/, [dɛˈgʊːla ˈɛplet], and in *ett gul-t hus* ‘a yellow house’ /et gʊlt hʊs/, [ɛtˈgʊːlt ˈhʊːs]. Here, the articles *det/ett* comprise unstressed pretonic syllables,

outside of the strong–weak structure. Further, the definite form suffix *–t* in *apple–t* is in the coda position of an unstressed syllable, and the neuter agreement inflection *–t* of *gul–t* is, although in a stressed syllable, the last consonant of a complex coda—both of which are challenging positions (Demuth, 2014). The low performance in general, and for the children with HI in particular (with a mean of only 0.5 out of 4), may partly have been due to the combined demands on phonological working memory and processing of segments and syllables in prosodically weak positions. The predicative agreement task is similar in this respect, with target structures between four and six syllables in length, and obligatory unstressed copula before a stressed syllable, as well as agreement expressed by suffixes comprising unstressed syllables or coda consonants (e.g. *hus–et är stor–t* ‘the house is big’ /hʊsət ɛr stʊrt/, [ˈhúːsət ɛˈstúːt]). A similar combination of phonological processing and phonological working memory load should be reflected in NWR performance (Gathercole, 2006; Bowey, 2006), but without the grammatical component. The present results on NWR showed a clear disadvantage for children with DLD or HI in comparison with the controls, but not for children with HI compared to those with DLD. This is in line with the results on the noun phrase agreement task, but not the predicative agreement task, which proved to be more difficult for the children with HI compared to children with DLD. So, while NWR did not capture a difference between the two clinical groups, the arguably more complex predicative agreement task did. The reasons for why children with HI should have more problems with this task cannot be explained based on the present findings, but warrants further investigation of the interface between working memory, phonology and grammar.

Grammatical production in the syntax subtasks emerged as a relative strength for the children with DLD or HI in the present study. This finding is somewhat surprising considering that syntactic impairments are common in both populations (Lederberg et al., 2013; Leonard,

2014). The tasks measuring production of negation placement, relative clauses, and topicalization word order require utterances with the right syntactical elements in the right order. With the exception of negations (*inte* 'not'), relative pronouns (*som* 'who/that') and topicalized words (e.g. *sen* 'then'), the child is free to choose any appropriate words as long as they belong to the correct syntactic category. Further, the requirements on phonetic and phonological accuracy is lower than in the morphology tasks, which likely also contributed to the more age-appropriate results on these tasks (Nitttrouer et al., 2014; Nitttrouer et al., 2016). It is possible that standardised tests that include only a limited variety of syntactic structures, such as the Gramba, do not capture important aspects of syntactic ability. Subsequently, tasks with higher syntactic complexity, or production in spontaneous speech or narratives, may reveal a different picture of syntactic production in children with DLD or HI. Still, the present results showed markedly higher results on the syntax subtasks compared to the verbal and nominal morphology tasks.

A limitation of the present study is that several factors that may influence both phonology and grammar were unaccounted for. For instance, between-groups differences in phonological and grammatical production would possibly have been more valid, had the groups been matched for e.g. lexicon size or quality. Future studies should also control more carefully for socio-economic status. The lower maternal education length in the HI group compared to the TLD group may have put the children with HI at a disadvantage. Differences in language ability between these two groups could therefore in part reflect e.g. unequal language stimulation in their home environments.

The findings of the present study need replication with larger sample sizes, especially given that the group of children with HI was small, with considerable heterogeneity. Also, more detailed analyses may provide insights into qualitative differences between the children with DLD and the children with HI. For example, the phonological production measures were exclusively quantitative, and do not capture e.g. what phonological features were problematic in each group.

V Implications

Large variability in the group of children with HI should be taken into account in the assessment of phonological working memory, phonological processing and production, and grammatical production. Some children performed on par with typically developing children with NH, while the majority achieved results below or well below age-adequate levels. The relative strength in syntactic ability in both children with DLD and children with HI may also have clinical implications, since this means that using e.g. syntactic bootstrapping in the treatment of e.g. phonological, lexical and grammatical impairments may be beneficial for these children. The demonstrated problems with both verbal and nominal morphology should also be taken into consideration in intervention planning.

VI Conclusions

The children with DLD and children with HI in the present study performed below controls on phonological production during naming and repetition of words and nonwords, as well as on verb and noun morphology. Production of tonal word accents emerged as a relative strength, as did syntax. Regarding both phonology and grammar, children with DLD and HI reached similar levels of performance, with the exception of noun–adjective agreement in

predicative, where children with DLD achieved higher scores. Future experimental studies of tasks that could discriminate between these groups are encouraged, as they might highlight language problems that are uniquely characteristic for each clinical population (DLD and HI).

Declaration of conflicting interest

The authors declare no potential conflicts of interest with respect to the research, authorship, or publication of this article.

Funding

The authors received no financial support for the research, authorship, or publication of this article.

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