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Learning by ear: on the acquisition of case and gender marking by German-speaking children with normal hearing and with cochlear implants*

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ABSTRACT

The acquisition of case and gender marking on the definite and indefinite article was studied in a sample of 6 normally-hearing children and 9 children with cochlear implants. Longitudinal spontaneous speech data are used. Children were matched by MLU, with 4 MLU levels: 1·8, 2·8, 3·6, 4·8. Age ranges for normally-hearing children were 1;4 to 3;8 and for children with cochlear implants 1;8 to 7;0. Frequencies of correctly marked article forms increased over MLU but less so in the hearing-impaired group. In both groups error rates were high. However, error patterns were different. In normally-hearing children errors of case predominated, in hearing-impaired children errors of gender and omission. Error patterns suggest that in normally-hearing children syntactic categorization interacts with input frequency and low discriminability of article forms. In the hearing-impaired group the article system is less advanced, despite higher frequencies of definite articles in adult speech. The predominance of article omission is discussed in terms of persisting perceptual problems or a working memory deficit.

INTRODUCTION

Cochlear implants are electronic devices that aim at replacing the cochlear function. Cochlear implantation has become increasingly popular for young

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congenitally deaf or prelingually deafened children, and a number of studies suggests that these children are capable of acquiring spoken language even though this may occur more slowly (Fryauf-Bertschy, Tyler, Kelsay, Gantz & Woodworth, 1997; Svirsky, Robbins, Kirk, Pisoni & Miyamoto, 2000; Szagun, 2001, 2002). Children with cochlear implants are comparable to children with mild to moderate hearing impairment (Bertram, 1991; Archbold & Tait, 1994). They are a child population with a particular deficit whose language acquisition may be compared to that of children with normal hearing. Such a comparison may not only contribute to understanding the effects of a perceptual deficit on language learning, but may also help to evaluate theories of typical language acquisition.

It would seem reasonable to assume that children with impaired hearing have particular problems with acquiring linguistic elements of low perceptual salience. In terms of grammatical markings, this would concern words or morphemes which lack stress or are hard to discriminate from one another. In German the article system is characterized by exactly these features. Articles are in unstressed prenominal position, and some article forms are hard to discriminate, i.e. *den* and *dem*. At the same time, articles are perhaps the most vital carriers of grammatical information in German, marking for case, gender, and numerosity. Thus, the acquisition of the article system would seem crucial for mastering grammar. If hearing-impaired children have particular problems with grammatical markings of low perceptual salience, this might affect their acquisition of articles and slow down or even prevent their construction of case and gender categories. In this way, the children's hearing impairment would have serious consequences for their acquisition of grammar.

What are the specific properties of the German article system? Forms of the definite and indefinite articles are presented in Tables 1 and 2, including contracted forms which occur in spoken language next to full forms. In the case of indefinite articles there may be several phonetic realizations of a particular article form. The article system is characterized by a low degree of perceptual discriminability of some forms. Forms such as *den* and *dem*, or *ein* and *einen* are hard to discriminate in spoken language, particularly as *einen* is usually contracted to *ein'n* which is spoken with a long [n]. Articles also tend to merge with prepositions and thus may become hard to distinguish. Instead of saying *auf den* (on theACC), *mit dem* (with theDAT), *von der* (from theDAT), German speakers say *auf'n*, *mit'm* and *von'er* (ending pronounced [ɐ]). Some of these amalgamations have the status of words, like *zum* (to theDAT), *zur* (to theDAT), *am* (at theDAT), *im* (in theDAT), others have not (Duden, 1995). The article system is further characterized by considerable homonymy. Ambiguity of form–function mapping is pervasive. In the definite and indefinite paradigms, nominative and accusative feminine (*die*, *eine*) as well as nominative and accusative

TABLE 1. *Forms* of the German definite article*

Case	Masculine	Feminine	Neuter	Plural
Nominative	der	die	das	die
Accusative	den	die	das	die
Dative	dem	der	dem	den
Genitive†	des	der	des	der

* Contracted forms occurred in forms merged with prepositions. These were *'n* for accusative masculine, *'m* for dative masculine and neuter, *'er* [ɐ] for feminine dative, and *'e* [ə] for feminine accusative.
† The genitive has not been reported in child language.

TABLE 2. *Forms* of the German indefinite article*

Case	Masculine	Feminine	Neuter
Nominative	ein	eine	ein
contracted	'n	'ne	'n
Accusative	einen	eine	ein
contracted	ein'n 'nen 'n	'ne	'n
Dative	einem	einer	einem
contracted	ei'm 'nem 'm	'ner	ei'm 'nem 'm
Genitive†	eines	einer	eines

* In the present sample percentage of contracted forms out of totals per case were: nominative masculine: 9·1; accusative masculine *ein'n*: 61·9, accusative masculine *'n*: 24·1; feminine nominative: 16·7; feminine accusative: 27·3; neuter nominative: 12·5; neuter accusative: 16·1. There were no differences between children and adults, nor between groups.
† The genitive has not been reported in child language.

neuter (*das*, *ein*) are formally identical, and so are nominative masculine and feminine dative (*der*) in the definite article paradigm. Only the accusative masculine forms *einen* and *den* in the singular mark accusative function unambiguously.

Due to the properties of the system – low perceptual salience and homonymy of forms – the acquisition of case marking in German is expected to be slow and error-ridden. Existing data from typically developing children point in this direction. Diary studies as well as analyses of recorded spontaneous speech have reported a protracted period of learning and many erroneous forms (Stern & Stern, 1928; Clahsen, 1984; Mills, 1985; Tracy, 1986; Eisenbeiss, 1994; Czepluch, 1996). According to diary studies children use nominatives first, followed by accusatives and datives (Stern & Stern, 1928; Mills, 1985). More recent data of recorded spontaneous speech appear to confirm this sequence (Clahsen, 1984; Tracy, 1986; Czepluch,

1996). Data from one child (Czepluch, 1996) indicate that datives are used predominantly after prepositions. Erroneous marking of case is pervasive. According to Clahsen (1984) who presents the most detailed quantitative analysis of correct and incorrect case markings based on speech samples from three children, children commit errors of omission and substitution. At MLU levels between 2·25 and 2·75 articles were left out by the children. At MLU level 3·5 the children used predominantly nominatives and overgeneralized these to contexts which require accusative or dative. At MLU level 4·0 accusatives were used more frequently than datives and overgeneralized to contexts requiring dative. This result is in agreement with observations from diary studies where the most frequent error was the use of accusative in a context requiring dative (Mills, 1985). The studies agree on the finding that nominatives and accusatives are used correctly earlier than datives, and that the acquisition of dative marking is slow. This finding is further supported by data using an experimental methodology. Testing children's productivity with case marking with nonce words Wittek & Tomasello (2002) found that German-speaking two to three-year-olds were less productive with dative marking than with nominative and accusative marking.

While these studies agree on the major findings, some questions remain. One is to what extent the results based on spontaneous speech data can be generalized. They come from very small and in some cases special samples, such as single case studies (Stern & Stern, 1928; Czepluch, 1996) or siblings including twins (Stern & Stern, 1928; Clahsen, 1984). Another problem concerns the sampling of speech. Often the size of speech samples on which specific error analyses are based remains unclear, and frequencies for correct and incorrect case markings are not presented (Tracy, 1986; Eisenbeiss, 1994; Czepluch, 1996). Clahsen's (1984) study is an exception to this. However, the total frequencies of accusatives plus datives on which his analyses are based are very low, 10, 13, and 44 per individual child. None of the studies presents a fine-grained qualitative and quantitative analysis of error patterns, for type of article and gender separately. Such an analysis, however, may yield results which are useful for theorizing about mechanisms of acquisition. Accusative, for instance, can be expressed by a definite or indefinite article. In the indefinite paradigm the accusative marked form *ein'n* is hard to discriminate from the nominative *ein*, whereas definite *den* is easily discriminated from the nominative *der*. If low perceptual discriminability influences the acquisition of a grammatical category such as case, it should take longer to use the indefinite form *einen* correctly than the definite form *den*, because *einen* – mostly pronounced *ein'n* – sounds very similar to nominative masculine and neuter *ein*. In fact Tracy (1986) noted such a discrepancy in the acquisition of accusatives in her data, but did not present substantial quantitative evidence. Finally, frequency information regarding

correct and erroneous case marking is needed in order to assess to what extent children have acquired case marking.

The present study aims to fill some of these gaps by presenting a fine-grained characterization of erroneous case marking in which article forms are separated by type of article and by gender, and by providing quantitative analyses of correct and erroneous use of articles at increasing MLU levels. The focus is on article use in the singular. The analyses will be based on more extensive sampling of children and of speech than in previous studies. Parents' use of articles will also be analysed using extensive sampling of child directed speech from the children's parents. The analyses aim at clarifying the influence of such parameters as perceptual salience and input frequency on article acquisition. While this study focuses on case, gender marking which is always co-occurrent with case marking in German is included. However, the acquisition of gender marking in the sense of learning associations of gender marked articles and particular lexical items is not studied here. Within case the focus is on inflectional learning, and not syntactic knowledge, such as sentence position of case marked objects, nor on case marking and lexical learning (see Eisenbeiss, 1994; Czepluch, 1996). By including a sample of hearing-impaired children the role of perceptual factors under a deficit condition can be assessed.

Inflectional learning is assumed to be influenced by a variety of factors from conceptual, perceptual, and distributional domains (Bates & MacWhinney, 1987; Akhtar & Tomasello, 1997). Within the German determiner system inflectional learning involves the inflectional markers *-e*, *-r*, *-(e)n*, *-(e)m*, *-s* (Wurzel, 1970, see Tables 1 and 2). Acquisition of case marking is expected to be slow because of a number of conceptual and perceptual difficulties.

In the conceptual domain the German article system is complex due to homonymy of forms. Children have to learn that one form expresses different grammatical categories or functions. Ambiguity of form–function mappings is more difficult for children than one-to-one form-to-function mappings (Slobin, 1985), because learning multiple associations to one form is a conceptually more demanding task than learning one-to-one associations. These difficulties in the conceptual domain can be assumed to have the same impact for children with normal and with impaired hearing.

In the perceptual domain, lack of salience of articles makes for difficulty. There are two aspects of perceptual salience which are relevant here. The first one is lack of stress. Articles are in unstressed prenominal sentence position, an article being followed by a stressed noun or adjective + noun. Another aspect of lack of perceptual salience is low discriminability of some forms, such as *den* and *dem*, or *ein* and *ein'n*. Lack of stress and low discriminability of forms should make case marking difficult to acquire, irrespective of a child's hearing status. Furthermore, low discriminability

of forms predicts specific errors and their preference, such as confusing the similar-sounding forms *ein/ein'n* and *den/dem*.

In children with impaired hearing the impact of perceptual difficulties should be enhanced. Because articles are unstressed these children may frequently miss them in the input altogether. This is likely to lead to an even slower build-up of the article system and to a specific error pattern in which errors of omission prevail. Low discriminability of similar-sounding forms should have a greater effect under a perceptual deficit condition, and thus hearing-impaired children should err on such forms more often than children with normal hearing. Thus, higher error frequencies involving *ein/ein'n* and *den/dem* are expected in the cochlear-implanted group.

Finally, distributional factors need to be considered. In terms of frequency articles are amongst the most frequently used words of German according to the CELEX database (Baayen, Piepenbroek & Guilikers, 1995). Thus, slow acquisition is not likely to be due to low adult input frequencies. However, input frequencies could be related to children's error preferences in the sense that children's most frequent errors correspond to the most frequently used article forms in adult speech. There is a suggestion in the diary data that *die* is the most frequent child error (Mills, 1985). Similarly, *die* occurred as the most frequent error in simulations, and this was explained by the fact that *die* is the most frequently used article form in German (MacWhinney, Leinbach, Taraban & McDonald, 1989). The relation between preferred error choice and adult frequency will be examined here on the basis of large child language corpora and large corpora of child directed speech. In addition, the input to normally-hearing and cochlear-implanted children will be compared. Previous research has found that hearing-impaired children often receive reduced and even grammatically impoverished input (Gallaway & Woll, 1994). If adult speech to children in the cochlear-implanted group is less rich in article forms, any observed differences in acquisition may be related to this reduced input. If input frequencies of articles do not differ in the two groups, any observed differences can be attributed to the effects of impaired hearing.

METHOD

Design and participants

The data for the present analysis are from two large corpora of spontaneous speech of children with normal hearing and children with cochlear implants (Szagun, 2001; MacWhinney, 2002). These corpora were collected within the context of a longitudinal study with 22 normally-hearing children and 22 cochlear-implanted children, 12 girls and 10 boys in each group. Speech samples were collected every $4\frac{1}{2}$ months over a period of up to 28 months for children in the normally-hearing group, and for a period of up to 36 months

for children in the cochlear-implanted group. Data recording started at 1;4 for the normally-hearing children and 6 months after cochlear implant surgery for the cochlear-implanted children, with ages ranging from 1;8 to 4;4. The children in the two groups were matched for initial language level (for details, see Szagun, 2001). For a subgroup of children in each group speech samples were recorded at closer time intervals. Six normally-hearing children were recorded every 5–6 weeks. Ten cochlear-implanted children were recorded every 10–12 weeks. Two hours spontaneous speech in a free play situation were audio recorded.

For purposes of the present analyses 6 children with normal hearing, 4 girls and 2 boys, and 9 children with cochlear implants, 5 girls and 4 boys, were selected. The aim was to compare children with similar MLUs so as not to confound progress in the case system with overall grammatical progress. Also, in order to get an adequate sampling of the use of case marking a reasonably large number of speech samples is needed. Thus, the children from both groups were selected on the basis of similar MLUs and a sufficient number of speech samples per child in which case marking occurred. For the normally-hearing group the 6 children recorded every 5–6 weeks were chosen, as 22 speech samples are available per child. For the cochlear-implanted group 9 children were selected. These children's linguistic progress did not differ from that of normally-hearing children, as measured by increase in MLU over a time period of 28 months from the beginning of data collection (see Szagun, 2001). For these 9 children between 8 and 12 speech samples per child are available. Out of the larger number of speech samples for the 6 normally-hearing children those were selected which matched the speech samples of the 9 cochlear-implanted children most closely in terms of MLU. The comparative analysis of case marking is performed at 4 MLU levels. Mean MLUs per level, the number of speech samples per MLU level and group, as well as the median of speech samples per individual child at each MLU level are presented in Table 3.

The 9 cochlear-implanted children were between 1;2 and 3;10 at the time of cochlear implant surgery, with a mean implantation age of 2;3 (*S.D.* = 0;8). They were pre-lingually deafened. (For a detailed description with biographical and audiological data for individual cochlear-implanted children, see Szagun, 2001.) During the period of data recording the children were between 1;8 to 7;0, as children's ages ranged between 1;8 and 4;4 at the beginning of data collection. The children attended Cochlear Implant Centre in Hanover, northern Germany, for rehabilitation, where they took part in an aural rehabilitation programme (Bertram, 1991). Eight children were resident in northern Germany, one in southern Germany. The children came from monolingual environments of spoken German, and they had no diagnosed handicap besides their hearing impairment.

TABLE 3. *Mean MLUs at four MLU levels, and total and median numbers of speech samples used for comparative analysis for normally-hearing (NH) and cochlear-implanted (CI) children*

Group	measure	Level 1	Level 2	Level 3	Level 4
		Mean (*S.D.*, range)	Mean (*S.D.*, range)	Mean (*S.D.*, range)	Mean (*S.D.*, range)
NH	MLU:	1·89 (0·26, 1·5–2·3)	2·86 (0·21, 2·5–3·1)	3·77 (0·33, 3·3–4·2)	4·82 (0·38, 4·3–5·4)
CI	MLU:	1·86 (0·27, 1·4–2·3)	2·84 (0·26, 2·4–3·4)	3·53 (0·34, 2·9–4·1)	4·83 (0·38, 3·9–5·4)
		Total number of speech samples per MLU level			
NH		16	15	16	19
CI		16	16	14	19
		Median number of speech sample per individual child			
NH		3	2	3	3
CI		2	2	2	2

Their IQs were within the normal range, as measured by Snijders-Oomen Non-verbal Intelligence Test (Snijders, Tellegen, Winkel, Laros & Wijnberg-Williams, 1996).

The 6 normally-hearing children had no diagnosed developmental delays. At the start of data collection at age 1;4, they demonstrated age-appropriate levels of object permanence knowledge as measured by the Infant Psychological Development Scales (Sarimski, 1987). The children were growing up in monolingual environments and were resident in Oldenburg, northern Germany. They were recruited for the study from two daycare centres in Oldenburg. During the period of data recording the children were between 1;4 and 3;8.

Data collection, transcription and MLU measurement

Data collection took place in playrooms at the respective institutions, the University of Oldenburg and the Cochlear Implant Centre, Hanover. The situation was free play with a parent and – most of the time – an investigator present and playing with the child. Toys were similar in the two settings: cars and garage, dolls, doll's house, zoo animals, farm animals, forest animals, picture books, puzzles, medical kit, ambulance, fire-station. Digital auditory tape recording was carried out, using portable Sony DAT-recorders and highly sensitive Sony or Aiwa microphones. In Oldenburg video recordings were also made, but not in Hanover where the smaller playroom did not allow non-intrusive video recording.

Everything spoken by the child and the first 500 parental utterances at each of the first 4 data points spaced $4\frac{1}{2}$ months apart were transcribed using CHILDES (MacWhinney, 2000). An adaptation of rules for transcribing contracted speech, for coding MLU and morphosyntax was developed and used (Szagun, 1999; MacWhinney, 2002). Rules for coding MLU follow Brown's (1973) rules as far possible. They differ in dependence on the specific inflectional morphology of German. In the context of the present paper coding of articles is of relevance and will be explained briefly. Gender marked nominatives of the definite article are encoded as one morpheme each *der*, *die*, *das*. Within the case paradigm changes from the nominative which are formally marked are counted as two morphemes, i.e. accusative masculine *de-n* and feminine dative *de-r*. Plural *di-e* is coded as two morphemes. The rationale for this is that children have made grammatical progress when they have learnt that *der* can change to *den*, *die* to *der*, and that across the gender paradigm *der*, *die*, *das* are *die* in the plural. This is consistent with the aim of MLU which is intended as a measure of grammatical progress. Case and gender marked forms of the indefinite article are coded separating the inflectional morpheme, i.e. *ein-e* or *ein-en*. For more details see Szagun (1999; MacWhinney, 2002).

Transcription was done from the DAT recordings using videos and written notes for contextual information. Eight transcribers who were trained extensively on using CHAT notations and transcription rules performed the transcriptions. Reliability checks on transcription were calculated for 7·3% of the total transcripts for different pairs of transcribers. Percentage agreements were between 96 and 100%. Coding for MLU and morphosyntax was performed by three researchers. Determiners were coded as part of the overall morphosyntactic coding. Reliability checks were done for 20% of the total transcripts, and Cohen's kappa used as a measure of reliability. Kappas were 0·94 for coders 1 and 2, 0·98 for coders 1 and 3, 0·96 for coders 2 and 3, indicating very good agreement between coders. CLAN programmes were used for calculating frequencies of morphosyntactic categories.

Coding scheme for erroneous article forms

A coding scheme for errors including incomplete forms was developed. The coding scheme presents the error categories and within each error category subtypes per case and per type of article (definite, indefinite) with examples.

1) *Protoforms*

For the definite article a form *de* [də] is used instead of *der*, *die*, *das*, *den*, *dem*. For the indefinite articles protoforms used are *a* [a], *ei* [ai], and *e* [ə] instead of *ein*, *eine*, *einen*.

Examples for the nominative: *de auto* (correct: *das auto*, 'the car'); *a wauwau* (correct: *ein wauwau*, 'a dog'); *da is ei tasche* (correct: *eine tasche*, 'there's a bag'); *da e teddy* (correct: *ein teddy*, 'a teddy').

Examples for the accusative: *de (s)tall wieder zumachen*, *Mama* (correct: *den stall*, 'close the barn, Mommy'); *ich will ei hund* (correct: *einen hund*, 'I want a dog'); *Mama hat a kopf* (correct: *einen kopf*, 'Mommy has a head').

Examples for the dative: *so mit de auto fahr'n* (correct: *mit dem auto*, 'move the car like this'); *von de mädchen* (correct: *vom dem mädchen* 'from the girl').

2) *Omissions*

The article is left out. Omissions are only coded from an MLU of 2·5 upwards in order to exclude children's two-word utterances when articles are typically omitted but would not be expected.

Examples for the nominative: *wo is telefon*? (correct: *wo is das telefon*? 'where is telephone?'); *ich bin junge* (correct: *ich bin ein junge*, 'I am boy').

Examples for the accusative: *will zoo aufbau'n da* (correct: *den zoo*, 'want to build zoo there'); *alle wieder in auto einsteigen* (correct: *in das auto*,

'everybody get into car again'); Examples: *ham wir garten* (correct: *einen garten*, 'we have garden'); *Lena hat jetz karte zu hause* (correct: *eine karte*, 'Lena has map at home now').

Examples for the dative: *moment*, *das muss ich bei kasse hinstellen* (correct: *bei der kasse*, 'just a moment, I have to put this near cash desk').

3) *Errors of gender*

In the nominative nouns are marked incorrectly for gender. In the definite paradigm each of the three article forms *der*, *die*, *das* can be substituted by one of the two others. In the indefinite paradigm *eine* is substituted by *ein*, and *ein* by *eine*. Examples: *die auto kann tanken* (correct: *das auto*, 'the car can fill up with petrol'); *die wolf* (correct: *der wolf*, 'the wolf'); *das hund auch* (correct: *der hund*, 'the dog too'); *wo der flasche*? (correct: die flasche, 'where the bottle?'); *ein katze* (correct: *eine katze*, 'a cat'); *eine eis* (correct: *ein eis*, neuter, 'an icecream').

In the accusative nouns are marked incorrectly for gender while case marking is correct. Each of the three definite forms *den*, *die*, *das* can be substituted by one of the two others, and in the indefinite paradigm each of the forms *einen*, *eine*, *ein* can be substituted by one of the two others.

Examples: *du den auto tanken* (correct: *das auto*, 'you fill up the car with petrol'); *so mach ich die fernseh'n an* (correct: *das fernseh'n*, 'that's how I turn the television on'); Examples: *eine eis haben*? (correct: *ein eis*, neuter, 'have an icecream?); *und weihnachten hat die zwei bücher und ein katze geschenkt* (correct: *eine katze*, 'and for Christmas she gave two books and a cat'); *noch eine pinsel* (correct: *noch einen pinsel* 'another paint brush').

4) *Errors of case*

Case is marked incorrectly while gender marking is correct. In the accusative errors of case occur in the masculine paradigm. Children use nominative instead of accusative, i.e. *der* instead of *den* and *ein* instead of *einen*. Examples: *ich mal der mond weg* (correct: *den mond*, 'I paint the moon away'); *ich seh auch ein schneemann* (correct: *einen schneemann*, 'I see a snowman, too').

In the dative errors of case with gender marked correctly occur as accusative or accusative/nominative error. In the masculine paradigm the accusative *den* is used instead of dative *dem*. In the feminine paradigm *die* is used instead of *der*, and in the neuter paradigm *das* is used instead of *dem*. The corresponding indefinite forms are *ein* instead of *einem*, *eine* instead of *einer*, and *ein* instead of *einem*. In the feminine and neuter paradigms it is impossible to tell whether children are using accusative or nominative in place of dative, as the two cases are marked by identical forms. Examples: *der war auf das dach* (correct: *auf dem dach*, 'he was on the roof'); *der*

feuerwehrmann muss den feuerwehrmann helfen (correct: *dem feuerwehrmann*, 'the fireman has to help the fireman'); *von die seite* (correct: *von der seite*, 'from the side'); *jetz kommt der tiger mit ein'n schneemannkopf an* (correct: *mit ein'm schneemannkopf*, masculine noun, 'the tiger is coming with a snowman's head now'); *das hab ich von eine pommesbude* (correct: *von einer pommesbude*, feminine noun, 'I have that from a fish-and-chips shop'); *zu ein krankenhaus* (correct: *zu einem krankenhaus*, neuter noun, 'to a hospital').

5) *Errors of case and gender*

Case as well as gender are marked incorrectly. These errors occur in the dative of the definite paradigm. The masculine accusative form *den* is used instead of feminine dative *der* and *dem* for a neuter noun. Feminine *die* is used instead of masculine and neuter dative *dem*. Neuter *das* is used instead of feminine *der* and masculine *dem*. Examples: *jetz is der mann wieder auf'n dach* (correct: *auf dem dach*, 'the man is on the roof again now'); w*ill auch mit die bauernhof spiel'n* (correct: *mit dem bauernhof*, 'want to play with the farm, too').

Errors in the samples were coded according to the above scheme by two independent coders. Errors which did not fit into the coding scheme were 4·5% for the normally-hearing group and 3·2% for the cochlear-implanted group. Such errors included the use of accusative instead of nominative (0·97%), dative instead of accusative or nominative (0·19%). Interrater reliabilities were calculated for 40% of the present speech samples using Cohen's kappa as a measure of interrater reliability. For the different cases kappas were: nominative definite article, 0·96; accusative definite article, 0·85; dative definite article, 0·90; nominative indefinite article, 0·84; accusative indefinite article, 0·89.

RESULTS

The present analysis focuses on correct and incorrect article use in the singular and is divided into 3 parts. First, frequencies of correct use of article forms are presented. Next, the use of correct and erroneous forms by normally-hearing and cochlear-implanted children is compared at 4 MLU levels. In the next section, error preferences within error categories are explored. In the final section, use of determiners in parental speech is analysed.

Use of correct and erroneous article forms at 4 MLU levels by normally-hearing and cochlear-implanted children

How often and at which MLU levels do children use correct article forms? Table 4 shows the frequencies of correct article forms per case over the 4 MLU levels for normally-hearing and cochlear-implanted children.

TABLE 4. *Total absolute frequencies of correct use of definite and indefinite articles per case and MLU level for normally-hearing (NH) and cochlear-implanted (CI) children*

Group MLU (NH/CI)*	Level 1 (1·89/1·86)	Level 2 (2·86/2·84)	Level 3 (3·77/3·53)	Level 4 (4·82/4·83)	Level 1 (1·89/1·86)	Level 2 (2·86/2·84)	Level 3 (3·77/3·53)	Level 4 (4·82/4·83)
	Definite article				*Indefinite article*			
NH ($n=6$)								
Case								
Nominative	25	231	474	843	135	547	568	731
Accusative	15	56	199	353	1	19	109	217
Dative	6	29	64	130	0	0	2	9
CI ($n=9$)								
Case								
Nominative	28	115	190	581	140	265	278	441
Accusative	1	42	39	198	2	18	51	144
Dative	5	25	32	188	0	3	0	1

* Mean MLU levels for the NH/CI group; number of speech samples per MLU level per group are nearly equal, see Table 3.

Because number of speech samples vary per child but are fairly similar for the total samples per group and MLU level (see Table 3), total absolute frequencies summed up over children per group are presented. Table 4 shows that in both groups correct nominative, accusative and dative article forms were used from MLU level 1, except for the dative of the indefinite article. Frequencies of correct article forms increased in all three cases over MLU levels. Nominatives were used more frequently than accusatives, and accusatives more frequently than datives.

The next analysis concerns the relative frequencies of erroneous, incomplete and correct use of articles. Frequencies are presented per case summing up over gender for this analysis (Figures 1–5). For dative and accusative frequencies are made up of articles used in direct object phrases and in prepositional phrases, and within the latter of articles used separately and articles merged with prepositions. The two groups of children did not differ in their use of articles in direct object or prepositional phrases. For both groups together relative frequencies for accusatives in direct object phrases were 61·3%, and in prepositional phrases 38·7%. For datives the figures were 2·8% in direct object phrases and 97·2% in prepositional phrases.

Definite article

Relative frequencies of form, i.e. error categories, incomplete and correct form, were compared for each case and type of article. Effects of form, MLU level, and group were tested by repeated measures analyses of variance with relevant *post-hoc* tests using the Scheffé test for repeated measures. Children with cochlear implants will be referred to as CI and normally-hearing as NH children. Data from only 3 MLU levels were used, level 2, 3, and 4, as article use on the first MLU level was too infrequent. The respective MLU means for the NH and CI groups were: level 2 = 2·86/2·84, level 3 = 3·77/3·53, level 4 = 4·82/4·83 (see also Table 4). An arcsine transformation was used for the relative frequency data.

For the nominative of the definite article a three-way ANOVA was calculated with repeated measures on (4) form: protoform, omission, gender errors, correct and MLU level (3), and group (NH, CI) as between-subjects factor. Mean frequencies and standard errors are presented in Figure 1. There was a significant main effect of form, $F(3, 39) = 76{\cdot}93$, $p < 0{\cdot}001$. The two-way form × group interaction was significant, $F(3, 39) = 3{\cdot}82$, $p < 0{\cdot}017$, as well as the two-way form × MLU level interaction, $F(2, 26) = 3{\cdot}45$, $p < 0{\cdot}004$. The three-way interaction of form × MLU level × group was also significant, $F(6, 78) = 2{\cdot}38$, $p < 0{\cdot}036$. In both groups of children correct article forms were significantly more frequent than any of the other forms at every MLU level (Scheffé, $p < 0{\cdot}05$). However, frequencies of correct forms were significantly larger for NH (normally-hearing) than for CI

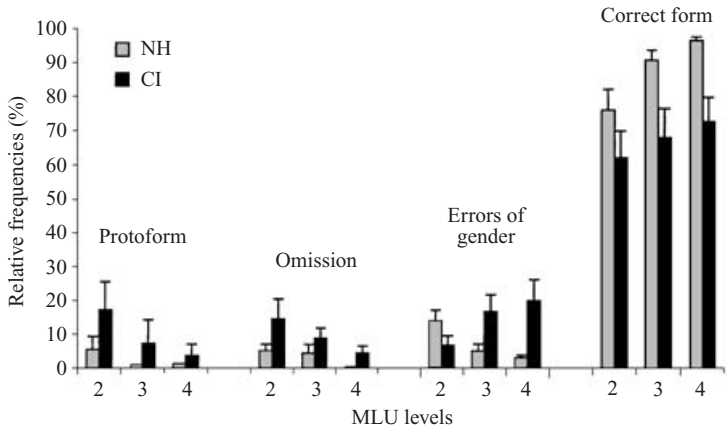

Fig. 1. Relative frequencies of correct and erroneous forms of the nominative of the definite article for normally-hearing (NH) and cochlear-implanted (CI) children over MLU levels.

(cochlear-implanted) children at MLU levels 3 and 4 (Scheffé, $p < 0{\cdot}05$). CI children made significantly more gender errors at MLU level 4 than NH children, (Scheffé, $p < 0{\cdot}05$). For the CI group errors of gender increased significantly over MLU levels 2 to 4, from 6 to 20%, while frequencies of protoform decreased significantly (Scheffé, $p < 0{\cdot}05$). At MLU level 4, the highest MLU level, errors of gender were the most frequent error type for CI children (Scheffé, $p < 0{\cdot}05$).

For the accusative of the definite article data for MLU levels 2 and 3 were collapsed, as absolute frequencies were too low for percentage calculations at separate levels. A three-way ANOVA with repeated measures on (5) form: protoform, omission, nominative error, gender errors, correct × (2) MLU level with group (NH, CI) as between-subjects factor rendered a significant main effect of form, $F(4, 52) = 39{\cdot}58$, $p < 0{\cdot}001$ and a significant two-way form × group interaction, $F(4, 52) = 5{\cdot}92$, $p < 0{\cdot}001$. Mean relative frequencies with MLU levels collapsed are presented in Figure 2. NH children used correct accusatives significantly more frequently than any of the other forms, whereas for CI children only nominative errors were less frequent than the other forms, including correct ones (Scheffé, $p < 0{\cdot}05$). NH children used significantly more correct forms than CI children, and CI children omitted articles significantly more frequently than NH children (Scheffé, $p < 0{\cdot}05$).

For the dative of the definite article data from all MLU levels were collapsed in order to have sufficient frequencies. A two-way ANOVA with repeated measures on (5) form: protoform, omission, accusative/nominative error, errors of case and gender, correct, and group (NH, CI) as between-subjects factor rendered a significant main effect of form, $F(4, 52) = 24{\cdot}09$,

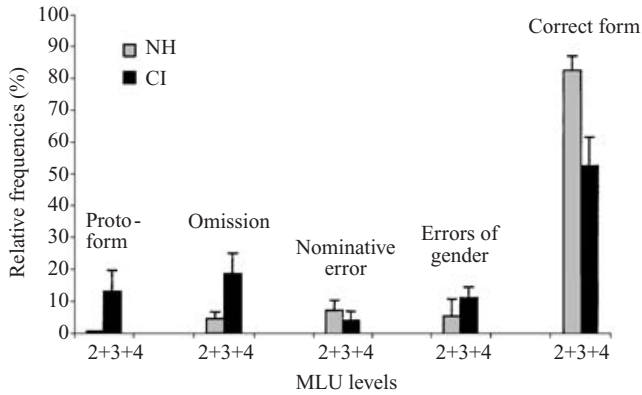

Fig. 2. Relative frequencies of correct and erroneous forms of the accusative of the definite article for normally-hearing (NH) and cochlear-implanted (CI) children over MLU levels collapsed.

$p < 0{\cdot}001$ and a significant two-way form × group interaction, $F(4, 52) = 2{\cdot}68$, $p < 0{\cdot}042$. Mean relative frequencies are presented in Figure 3. NH children used correct datives significantly more frequently than any other form (Scheffé, $p < 0{\cdot}05$) except the accusative/nominative error. CI children used correct datives significantly more frequently than any other form (Scheffé, $p < 0{\cdot}05$) except omissions. In the NH group accusative/nominative errors reached 27% and were significantly higher than protoforms (Scheffé, $p < 0{\cdot}05$). CI children used omissions most frequently, at a level of 25%, and significantly more frequently than NH children (Scheffé, $p < 0{\cdot}05$). Thus, the preferred error type for NH children was an error of case, whereas it was an error of omission for the CI children.

Indefinite article

For the nominative of the indefinite article data were analysed at 3 MLU levels. A three-way ANOVA, (4) form: protoform, omission, gender errors, correct × (3) MLU level as within-subjects factors, and group (NH, CI) as between-subjects factor was calculated. Main effects of form, $F(3, 39) = 194{\cdot}00$, $p < 0{\cdot}001$, and MLU level, $F(2, 26) = 8{\cdot}91$, $p < 0{\cdot}001$ were significant. The form × group and form × MLU level two interactions were also significant, $F(3, 39) = 7{\cdot}49$, $p < 0{\cdot}001$ and $F(2, 26) = 3{\cdot}85$, $p < 0{\cdot}002$. Mean relative frequencies are presented in Figure 4. For the two groups of children collapsed correct article forms were significantly more frequent than any of the erroneous forms, and correct forms increased significantly between MLU level 2 and 4, whereas protoforms decreased (Scheffé, $p < 0{\cdot}05$). CI children committed significantly more errors of gender, up to

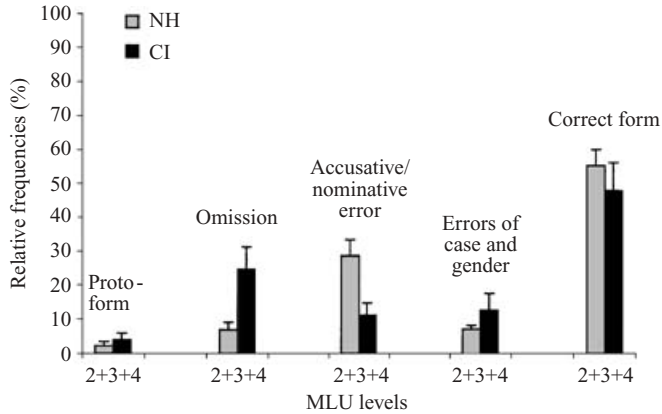

Fig. 3. Relative frequencies of correct and erroneous forms of the dative of the definite article for normally-hearing (NH) and cochlear-implanted (CI) children over MLU levels collapsed.

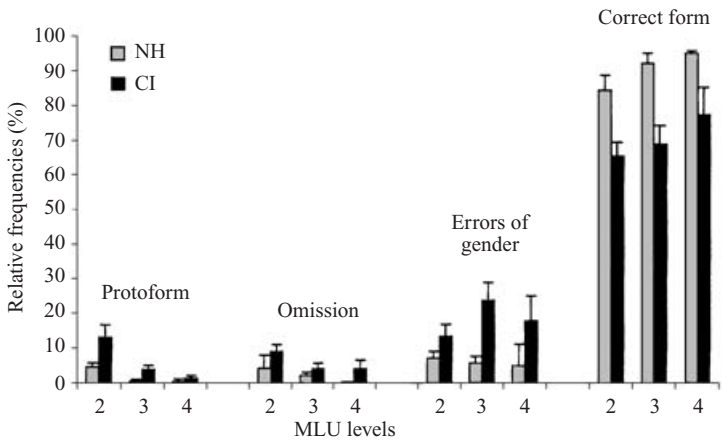

Fig. 4. Relative frequencies of correct and erroneous forms of the nominative of the indefinite article for normally-hearing (NH) and cochlear-implanted (CI) children over MLU levels.

24%, than NH children, whereas the latter used significantly more correct forms (Scheffé, $p < 0{\cdot}05$).

For the accusative of the indefinite article MLU levels 2 and 3 were collapsed to have sufficient frequencies. A three-way ANOVA, (5 form: protoform, omission, nominative error, gender errors, correct) × MLU level (2) as within-subjects factors, and group (NH, CI) as between-subjects

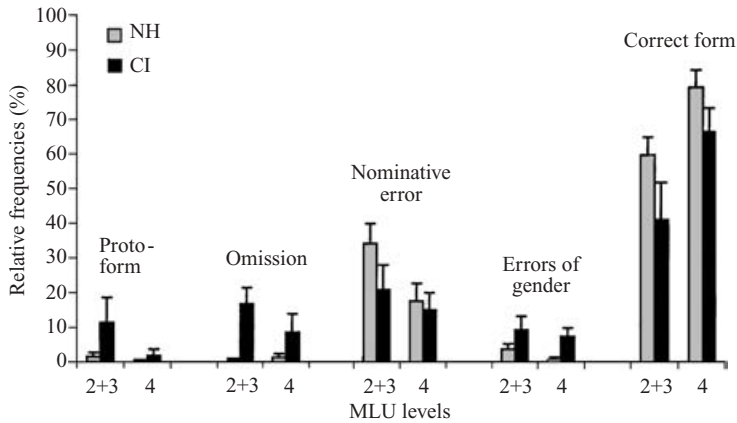

Fig. 5. Relative frequencies of correct and erroneous forms of the accusative of the indefinite article for normally-hearing (NH) and cochlear-implanted (CI) children over MLU levels.

factor was calculated. There was a significant main effect of form, $F(4, 52) = 43{\cdot}83$, $p < 0{\cdot}001$. The two-way interaction of form × group was significant, $F(4, 39) = 3{\cdot}11$, $p < 0{\cdot}023$, as well as the form × MLU level interaction, $F(4, 52) = 4{\cdot}42$, $p < 0{\cdot}004$. Mean relative frequencies are presented in Figure 5. At both MLU levels for the two groups collapsed, the nominative error was significantly more frequent than any other error type, between 15 and 34% (Scheffé, $p < 0{\cdot}05$). NH children used significantly more correct accusatives than erroneous ones (Scheffé, $p < 0{\cdot}05$), except for the nominative error, whereas for CI children only protoforms were significantly less than correct ones (Scheffé, $p < 0{\cdot}05$). Finally, CI children omitted the article significantly more frequently than NH children (Scheffé, $p < 0{\cdot}05$).

No statistical analysis was performed for dative forms of the indefinite article, as frequencies per child, even if summed over all data points, remained too low for relative frequency calculations.

Error preferences within error categories

Do children prefer certain errors within a particular error category? This was explored for errors of gender in the nominative and for errors of case and gender in the oblique cases, per type of article. The analysis is based on all 22 speech samples per child for the normally-hearing children and 8 speech samples per child for the cochlear-implanted children. Mean number of errors per individual, erroneously used form was compared per case, type of article, and per hearing group by one-way analyses of variance. Means and standard errors are presented in Table 5. For the dative, errors

TABLE 5. *Means of erroneously used forms per case, type of article, and group of children*

Group	Definite article Means (S.E.)				Indefinite article Means (S.E.)		
			Errors of gender in the nominative				
	der	*die*	*das*		*ein*	*eine*	
NH ($n=6$)*	9·2 (3·0)	12·2 (2·4)	6·2 (1·3)		23·3[a] (5·0)	5·0[a] (4·1)	
CI ($n=9$)†	8·1 (3·7)	11·3[a] (2·6)	1·1[a] (0·5)		21·6[a] (5·0)	6·8[a] (2·1)	
			Errors of case and of gender in the accusative				
	der	*den*	*die*	*das*	*ein*	*eine+einen*	
NH ($n=6$)*	9·2 (5·3)	6·5 (3·3)	3·3 (1·2)	2·2 (0·9)	33·7[a] (4·8)	0[a]	
CI ($n=9$)†	1·4 (0·4)	2·1 (0·9)	2·4 (1·2)	0·7 (0·3)	8·7[a] (1·9)	1·2[a] (0·8)	
			Errors of case, and of case and gender in the dative				
	den	*die*	*das*		*ein*	*eine*	*einen*
NH ($n=6$)*	35·2[ab] (5·6)	12·7[a] (5·5)	3·8[b] (1·2)		2·7 (1·9)	0·3 (0·2)	2·7 (1·0)
CI ($n=9$)†	5·1 (2·0)	3·6 (1·0)	0·8 (0·2)		Too few data		

* 22 speech samples per child.
† 8 speech samples per child.
[ab] Means within a group and article paradigm differ significantly (Tukey's *H.S.D.*, $p<0·05$, all t-tests, $p<0·026$).

of case and errors of case and gender are collapsed because of low numbers in the last category. Erroneous use of the nominative forms *der*, *die*, *das* of the definite article did not differ in the group of normally-hearing children. For the cochlear-implanted group a one-way ANOVA with repeated measures on form (3) *der*, *die*, *das* rendered a significant effect of form, $F(2, 16) = 3{\cdot}77$, $p < 0{\cdot}046$. *Die* was used erroneously significantly more frequently than *das* (Tukey's *H.S.D.* for repeated measures, $p < 0{\cdot}05$). When children made gender errors in the nominative of the indefinite article, *ein* was significantly more frequent than *eine* in either group, $t(5) = 3{\cdot}13$, $p < 0{\cdot}026$ for the NH group, and $t(8) = 2{\cdot}98$, $p < 0{\cdot}018$ for the CI group. In the accusative there were no differences in frequency of erroneous use of *der*, *den*, *die*, *das* in either group of children. For forms of the indefinite article, however, *ein* was significantly more frequent than *einen*, $t(5) = 7{\cdot}01$, $p < 0{\cdot}001$ for the NH group, and $t(8) = 3{\cdot}67$, $p < 0{\cdot}006$ for the CI group. For frequencies of erroneous use of *den*, *die*, and *das* as datives, a one-way ANOVA rendered a significant effect of form, $F(2, 10) = 16{\cdot}99$, $p < 0{\cdot}001$, for the NH group, but not for the CI group. In the NH group *den* was the most frequent dative error, and significantly more frequent than *die* and *das* (Tukey's *H.S.D.*, $p < 0{\cdot}05$). In the CI group there was no preference for any form. Erroneously used forms of the indefinite article in the dative did not differ for NH children, and were not analysed statistically for the CI group because frequencies were very low.

In order to clarify the role of low discriminability in error choice it is necessary to compare 1) *den* errors involving the *den/dem* substitution and *den* errors involving other substitutions, and 2) *ein* errors involving the *ein/ein'n* substitution versus the *ein/eine* substitution. 1) *Den/dem* substitutions are made up of dative case errors in the masculine paradigm plus case and gender errors in the neuter paradigm. *Den* errors not involving the *den/dem* substitution are substitutions of *die* or *das* as gender errors in the accusative plus case and gender errors where *den* substitutes dative feminine *der*. In the NH group the number of *den/dem* substitutions was significantly larger than *den* errors substituting other forms, $t(5) = 3{\cdot}81$, $p < 0{\cdot}013$. In the CI group there was no difference between the two types of *den* errors. 2) In the NH group the number of *eine/ein'n* substitutions did not differ significantly from *ein/eine* substitutions. In the CI group the number of *ein* substitutions for *eine* was significantly larger than the number of *ein/ein'n* substitutions, $t(8) = 3{\cdot}49$, $p < 0{\cdot}008$. Means and standard errors, as well as relative frequencies (%) out of the total of *den* and *ein* errors are presented in Table 6.

Adult use of articles

In this section adult use of articles in the singular is explored. Use of determiners in parental speech (mostly mothers) was analysed using 2000

TABLE 6. *Means and relative frequencies* (%) *of* den *and* ein *errors involving the similar-sounding* den/dem, ein/ein'n *and other substitutions per group of children*

Group	Type of substitution		Type of substitution	
	den/dem	*den/die, das, der*	*ein/ein'n*	*ein/eine*
	Mean (*S.E.*)			
NH ($n=6$)*	34·8[a] (5·6)	6·8[a] (3·4)	33·7 (4·8)	23·3 (5·1)
CI ($n=9$)†	4·7 (2·0)	2·6 (1·2)	8·7[a] (1·9)	21·6[a] (5·0)
	Relative frequencies (%) out of total			
NH ($n=6$)*	83·6	16·4	59·1	40·9
CI ($n=9$)†	64·6	35·4	28·6	71·4

* 22 speech samples per child.
† 8 speech samples per child.
[a] Means within a group and article paradigm differ significantly (all *t*-test, $p<0{\cdot}013$).

utterances per adult. These are the sum of 500 utterances at each of the first 4 data points spaced $4\frac{1}{2}$ months apart. For dative and accusative frequencies are made of articles used in direct object phrases and in prepositional phrases, and within the latter of articles used separately and articles merged with prepositions. Mothers of normally-hearing and mothers of cochlear-implanted children did not differ in their use of articles in direct object or prepositional phrases. For both groups together relative frequencies for accusatives in direct object phrases were 63·3%, and in prepositional phrases 36·7%. For datives the figures were 2·1% in direct object phrases and 97·9% in prepositional phrases. These figures are very similar to child frequencies (see beginning of Results Section). Occasionally, adults committed errors. These were of two types, they used *den* instead of *dem* or *ein* instead of *einen*. Relative frequencies of these errors were extremely low, 0·14% for *den/dem* and 0·33% for *ein/einen* for both groups collapsed.

Frequencies of use of definite and indefinite articles for mothers in the different groups of children were compared per case, for those cases which were analysed in child speech. For the definite paradigm a two-way ANOVA was run with repeated measures on case (3) nominative, accusative, dative, and group (NH, CI) as between-subjects factor. There was a significant effect of case, $F(2, 26)=65{\cdot}02$, $p<0{\cdot}001$, and a significant effect of group, $F(1, 13)=6{\cdot}56$, $p<0{\cdot}024$. In both groups nominatives were significantly more frequent than accusatives, and accusatives significantly more frequent than datives (Scheffé, $p<0{\cdot}05$). Mothers of CI children used significantly more definite articles in the nominative and accusative than mothers of NH children (Scheffé, $p<0{\cdot}05$). Table 7 shows the mean absolute frequencies per type of article and case. For the indefinite article

TABLE 7. *Mean absolute frequencies (S.E. in brackets) of adult article use per case and per group*

		Definite article:	
	Nominative	Accusative	Dative
NH ($n=6$)	152·8[a*] (19·1)	83·3[ab†] (7·8)	60·0[ab] (5·1)
CI ($n=9$)	217·3[a*] (18·0)	121·5[ab†] (10·4)	66·4[ab] (8·9)
	Indefinite article:		
	Nominative	Accusative	
NH+CI ($n=15$)	148·1[a] (12·5)	44·9[a] (4·2)	

[ab] Means between case and within group differ significantly (Scheffé, $p<0·05$).
*† Means between groups differ signficantly (Scheffé, $p<0·05$).

a two-way ANOVA with case as within-subjects factor (2) nominative, accusative, and group (NH, CI) as between-subjects factor rendered a significant effect of case, $F(1, 13)=90·44$, $p<0·001$. Nominatives were significantly more frequent than accusatives (Scheffé, $p<0·05$).

The final question is, whether children's preferred errors correspond to the most frequent article form in adult use. This analysis ignores the different functions a particular form can have. For instance frequency of use of *die* collapses *die* used as nominative and accusative singular and plural. Tables 8 and 9 show erroneously used article forms by children in rank order of descending frequency and article forms in adult speech rank ordered according to descending frequency. Mean absolute frequencies are also given. These are means out the total of articles per form irrespective of function and summed up over child age levels. Means are comparable for both adult groups, as numbers are based on an equal number of speech samples. For child groups means of absolute frequencies are not comparable, as they are based on different numbers of speech samples in the two groups. For the indefinite article there was a perfect fit. The form *ein* was the most frequent in adult speech and it was used most frequently in erroneous function by children. For the other forms also, error rates and adult frequencies corresponded. In the definite article paradigm adults used *die* most frequently, and this form corresponded to the most frequent error in the CI group, but only the second most frequent error in the NH group. The most frequent error *den* for NH children was the least frequent form in adult speech. The *der* error occupied rank 3 in the NH group and rank 2 in adult frequencies. This relationship was the other way round for the CI group. Thus, for the definite article paradigm frequency of use in adult speech and error preferences by children corresponded moderately to less well.

DISCUSSION

The use of definite and indefinite articles was compared in 6 normally-hearing children and 9 hearing-impaired children with cochlear implants.

TABLE 8. *Mean absolute frequencies of children's erroneous forms collapsed over function in descending order and mean absolute frequencies in adult speech in descending order for definite articles*

	Definite article							
	NH group ($n=6$)				CI group ($n=9$)			
Rank	Child error, mean (*S.D.*) (22 speech samples)		Adult frequency, mean (*S.D.*) (4 speech samples)		Child error, mean (*S.D.*) (8 speech samples)		Adult frequency, mean (*S.D.*) (4 speech samples)	
1	den	41·7 (17·1)	die	117·8 (31·1)	die	17·3 (11·9)	die	136·1 (46·6)
2	die	28·2 (13·5)	der	77·5 (27·7)	der	9·5 (12·0)	das	108·8 (26·4)
3	der	18·3 (17·1)	das	60·0 (21·6)	den	7·2 (6·8)	der	92·3 (25·1)
4	das	12·7 (4·1)	dem	42·5 (9·5)	das	2·5 (2·1)	den	53·0 (16·5)
5	(dem)*		den	39·7 (7·6)	(dem)*		dem	42·0 (20·7)

* Erroneous use of *dem* occurred extremely rarely (0·19% out of the total of errors) and is subsumed in the category 'Other' (see *Coding scheme* in the Methods Section).

TABLE 9. *Mean absolute frequencies of children's erroneous forms collapsed over function in descending order and mean absolute frequencies in adult speech in descending order for the indefinite articles*

	Indefinite article							
	NH group ($n=6$)				CI group ($n=9$)			
Rank	Child error, mean (*S.D.*) (22 speech samples)		Adult frequency, mean (*S.D.*) (4 speech samples)		Child error, mean (*S.D.*) (8 speech samples)		Adult frequency, mean (*S.D.*) (4 speech samples)	
1	ein	59·7 (21·0)	ein	111·3 (33·4)	ein	30·3 (20·1)	ein	132·7 (39·1)
2	eine	5·3 (3·9)	eine	44·0 (13·5)	eine	7·9 (8·1)	eine	48·6 (26·6)
3	einen	2·7 (4·7)	einen	19·8 (8·2)	einen	0·11 (0·33)	einen	17·1 (5·6)
4	*		einem	1·4 (1·0)	*		einem	3·0 (2·92)

* Erroneous use of *einem* in child language did not occur.

The children were matched for MLU. Comparisons were performed at 4 MLU levels, with mean MLUs of 1·8, 2·8, 3·7, and 4·8. Children in both groups used article forms in the nominative, accusative and dative from MLU 1·8. Frequencies of article use in all three cases increased over MLU. Nominatives were more frequent than accusatives, and accusatives more frequent than datives. In the normally-hearing group use of correct forms reached 90% in the nominative, but remained below that for the accusative,

particularly in the indefinite paradigm, and reached only around 50% in the dative. In the hearing-impaired group use of correct forms was less frequent. Children's erroneous article use consisted of protoforms, omission of articles, and errors of substitution, such as using the wrong case or wrong gender. Error rates were high in both groups, but the two groups displayed different error patterns. In the normally-hearing group error rates were highest for errors of case. The majority of these involved accusative *den* instead of dative *dem* and nominative *ein* instead of accusative *einen*. The predominant errors in the hearing-impaired group were errors of gender and of omission. Errors of gender prevailed in the nominative and increased over MLU. Errors of omission prevailed in the oblique cases. Both error types were more frequent than in the normally-hearing group. The different error patterns are suggestive of a more advanced case system in normally-hearing children who err within the case system, whereas the hearing-impaired children do not have much of a case system yet and have a less well established gender system.

In both groups the form *ein* was the most frequent error overall, i.e. collapsed over grammatical function, in the indefinite paradigm. Looked at separately by grammatical function, *ein* was also the most frequent error of gender in the nominative, and the most frequent error of case in the accusative. For both groups there was a perfect correspondence between rank order of error preferences and frequencies of adult use of articles in the indefinite paradigm. In the definite paradigm *die* was the most frequent overall error in the hearing-impaired group, and this corresponded to the most frequent adult form. In the normally-hearing group the most frequent overall error was *den* used as dative which did not correspond to adult frequencies of use of *den*. In the normally-hearing group the vast majority of *den* errors involved substitutions of the similar-sounding form *dem*. There were no error preferences for similar-sounding forms in the hearing-impaired group. In adult child directed speech nominatives were used more frequently than accusatives, and accusatives more frequently than datives. Mothers of cochlear-implanted children used significantly more definite articles in the nominative and accusative than mothers of normally-hearing children.

How do the present results for normally-hearing children compare with previous results? The present data confirm the picture of slow and error-ridden acquisition of case marking on articles in German-speaking children. However, the suggestion of an acquisitional sequence with nominatives being acquired before accusatives and datives (Stern & Stern, 1928; Clahsen, 1984; Tracy, 1986; Czepluch, 1996) is, at best, an imprecise way of describing the data. According to the present data, there is no such acquisitional sequence when initial use of articles over MLU levels is considered, as articles are used in all cases from MLU level 1·8. There is such

an acquisitional sequence, however, in the sense of nominatives achieving higher levels of correct use than accusatives and datives. Where the present data differ considerably from previous data is with respect to the use of articles at specific MLU levels. While Clahsen (1984) reports omission of articles at MLU level 2·75 and almost only nominatives at MLU level 3·5, the children in the present sample were not only using articles but also case marked article forms from MLU levels around 1·8. At MLU levels around 3·5 case marked forms were frequent. Although Clahsen's MLU calculations may not be comparable to ours because he used rules for English (see Clahsen, 1984), this is still a large discrepancy. It can probably be explained by the very low sample of case marked forms in Clahsen's (1984) analysis and his use of a sample of twins who seemed to acquire language rather slowly. The present data is likely to be more representative of German-speaking children.

The hypothesis of children's error preferences corresponding to the most frequent adult forms is confirmed for the total frequencies of *die* and *ein* errors in the hearing-impaired group, but only for the *ein* error in the normally-hearing group. The most frequent error *den* in the normally-hearing group cannot be accounted for by adult frequency, nor do the present results concord with the early diary evidence (Mills, 1985) and simulation results (MacWhinney *et al.*, 1989) of *die* being the most frequent error. In the case of diary evidence this discrepancy may again be due to insufficient sampling of speech and, in the case of simulations, to type of input to the network. Altogether, error preferences and adult frequencies correspond more strongly for hearing-impaired children than for typically developing children.

The hypothesis of error preferences for similar-sounding forms is confirmed for the *den/dem* error for typically developing children. As input frequency can be excluded and *den* is used with overwhelming frequency to replace *dem* as opposed to other forms, this error is attributed to low discriminability of forms and children's tendency to resort to a form which is already better established in their case system. The preference for the *ein/ein'n* error which shows up in terms of relative frequencies in the accusative does not show up when absolute frequencies of *ein/ein'n* substitutions are compared to *ein/eine* substitutions. Children do not substitute *ein* for *ein'n* more frequently than *ein* for *eine*. Therefore it seems reasonable to attribute the *ein/ein'n* substitution to the influence of adult frequency of the form *ein*, particularly as this frequency is extraordinarily high (see Table 9).

What do the observed error preferences mean for the construction of the case system? Because of the different error patterns I will discuss this question separately for the normally-hearing and hearing-impaired children. For the normally-hearing group error analysis suggests that syntactic categorization interacts with frequency of use and low discriminability

of article forms. Some case errors indicate that erroneous grammatical categorization is operative irrespective of perceptual or frequency factors, for instance when children use nominative *der* instead of accusative *den* in the masculine paradigm, and when they use *die* instead of *der* (femDAT) and *das* instead of *dem* (neuDAT). However, for similar-sounding case marked forms, such as *den* and *dem*, case errors are very much higher, even though *den* is not frequent in adult language. When erroneous case marking makes use of a highly frequent form, such as *ein*, error rates are much higher too. As a result there are far more case errors in the accusative of the indefinite paradigm than the definite paradigm where *der*/*den* errors are low. This leads to a temporal dissociation in the acquisition of accusative across article paradigms. Previous models of article acquisition (Clahsen, 1984; Tracy, 1986) have not taken this discrepancy into account but postulate a differentiation of nominative into accusative as an acquisitional sequence, irrespective of article paradigm and formal case marking. The models equate an abstract linguistic distinction of syntactic categorization with a developmental process which occurs over time and includes mastery of the different formal realizations of such a distinction. The present results show that the developmental learning process is not a mirror of abstract syntactic categorization. The construction of case categories is influenced by non-grammatical factors, such as the acoustic properties of formal markings and frequency of forms in adult language.

For the hearing-impaired children the prediction of an error pattern in which omission of articles prevails is confirmed, particularly for the oblique cases. However, contrary to expectation, hearing-impaired children do not commit more errors involving similar-sounding forms than normally-hearing children, whether absolute or relative frequencies are considered. Another finding was that they produce more errors of gender in the nominative which even increase at higher MLU levels. The prevalence of article omission in the oblique cases, struggling with gender at high MLU levels when normally-hearing children have almost mastered gender, point to a less advanced case and gender system in the hearing-impaired children. Slower overall grammatical development cannot account for this, because the two groups were at the same MLU levels.

How can these specific deficits in the case and gender system be explained? If, due to their hearing impairment, these children frequently miss unstressed prenominal articles in incoming speech, this would lead to a reduced frequency of actually processed article input. Omitting articles in production would seem a direct consequence of not taking them in. Omissions would be more prominent in the oblique cases because articles in object phrases are in sentence-medial position and acoustically less prominent than nominatives which tend to be in a sentence-initial nominal phrase. The frequent errors of gender can also be explained by reduced

frequencies of actually processed articles. Noun gender in German is probably largely learnt via associating a particular lexical item with a gender marked determiner. If article processing is less frequent, the strength of a particular article–noun connection will be weaker.

While this explanation may hold, it does not specify whether the deficits in article production are due to a weakness in the perceptual or cognitive processing system. If deficient auditory processing, i.e. a perceptual deficit, is at the root of hearing-impaired children's deficits, one would expect an effect on the production of similar-sounding forms as well. But this was not observed. One explanation could be that hearing-impaired children's case system has not yet reached a point where such erroneous forms become frequent. In fact, the absolute frequencies of correct and erroneous accusatives and datives displayed in Tables 4–6 are much lower than for the normally-hearing group, even taking into consideration that the frequencies in Tables 5 and 6 are based on fewer speech samples. This would support such an interpretation. An alternative explanation is that the observed deficits in the article system do not result from persisting perceptual problems but from a deficit in short term working memory. Recent research with children using cochlear implants has demonstrated shorter working memory spans in these children in a variety of tasks involving digit span, verbal and visual material (Cleary, Pisoni & Geers, 2001; Pisoni & Cleary, in press). It is suggested that children with cochlear implants may undergo atypical working memory development as a result of their early auditory deprivation (Pisoni & Cleary, in press). What may be disrupted is the building up of neural pathways within attentional networks which involve the processing of auditory information in working memory. Such pathways are built in the first and second year of life (Rothbart & Posner, 2001). Less efficient working memory would explain the predominance of article omission. Due to their memory limitations, children may have developed a communicative strategy which aims at preserving semantic information in content words to the neglect of other information. Support for this interpretation comes from empirical evidence for the primacy of processing semantic information in adult cochlear implant users, measured by event-related potentials (Hahne, Wolf, Kiefer & Müller, 2001). If working memory deficits are at the root of hearing-impaired children's deficits in article production, this would mean that their language problems are not a direct consequence of deficits in the perceptual system but are mediated via a central cognitive process and possibly the construction of different neural pathways during the children's developmental history.

In both groups of children the dative is acquired most slowly, irrespective of the different error preferences. Why do children take so long to acquire dative markings correctly? One explanation could be that datives occur almost exclusively after prepositions. The essential semantic information is

encoded by the preposition. From the point of view of conveying meaning case marking on the following article is less essential than case marking on a direct object. Furthermore, datives are less frequent in adult speech than accusatives, and this may contribute to their slow acquisition. Another explanation could be that it takes a long time to learn the different prepositions in their combination with dative case marking. Such learning may occur on an item-by-item basis, a type of grammatical learning stressed by Lieven, Pine & Baldwin (1997). In acquiring datives children might learn whole phrases like 'in the car' or 'on the table' – in which the article would be marked as dative in German – and they may use correct case marking only in a particular whole phrase containing a particular noun. If this was the case, it would take some time before children had enough variability in the combinations of preposition + dative article + noun to use correct dative marking irrespective of specific nouns.

For the hearing-impaired group the present results show that these children's less advanced article system is not due to reduced adult input. Parents of cochlear-implanted children produced even more definite articles than parents in the normally-hearing group. Yet, this enriched input does not seem to help children to the extent that they construct an article system equivalent to that of normally-hearing children, at least not during the time period of the present observations. The difficulties hearing-impaired children experience in constructing a case and gender system are due to processing limitations. While such processing limitations may have their root in a perceptual deficit, they may become a linguistic cognitive deficit during the children's developmental history. The implications of the present results for theories of grammar acquisition are that developmental pathways and outcomes are influenced by the specific conditions of the organism and are not sufficiently explained by an exclusive focus on linguistic categories.

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