First Language, **21** (2001), 109–141. Printed in England

Learning different regularities: the acquisition of noun plurals by German-speaking children*

GISELA SZAGUN, *University of Oldenburg*

ABSTRACT

The acquisition of German noun plurals was examined on the basis of two-hour spontaneous speech samples from 6 children between 1;4 and 3;8 recorded every 5–6 weeks, and from 15 children recorded every 20 weeks. Adult speech was also sampled. Onset of use of plural forms was early, with variation in individual growth rates of type frequencies. Children used the different German plural markings from early on. Growth rates of type frequencies per different plural class corresponded to adult frequencies, with *-n* and *-e* plurals displaying fastest growth. At age 2;10 relative type frequencies per plural class differed from adult use, but not at age 3;8. Errors were produced from the beginning, with high error rates. Major error types, *-n*, *-s*, partial marking, and no marking did not differ in frequencies. Error patterns reflected the regularities of the German plural marking system.

Empirical studies of the acquisition of English inflectional morphology have shown that children first use some regular and irregular forms correctly, then pass through a period of correct and incorrect use of inflections, and finally approach correct use of regular and irregular

---

* This research was funded by Deutsche Forschungsgemeinschaft, grant No. Sz 41/5-1/2. I am most grateful to the children and their parents who so willingly participated in this study. Sonja Arnhold-Kerri, Tanja Hampf, Elfrun Klauke, Stefanie Kraft, Dagmar Roesner, Rike Steenken, Claudia Steinbrink, Bettina Timmermann and Sylke Wilken assisted in data collection, transcription and data analysis. Discussions with Petra Arndt, Adele Diederich and Karin Zimmer helped to improve this work. I would like to thank them all. Address for correspondence: Institut für Kognitionsforschung, Fb 5, Psychologie, Gebäude A6, Universität Oldenburg, Postfach 2503, 26111 Oldenburg, Germany. E-mail: gisela.szagun@uni-oldenburg.de

0142-7237/01/2102-0109 $5.00

inflections (Marcus, Ullman, Pinker, Hollander, Rosen & Xu 1992, Miller & Ervin 1964). This route has been referred to as a U-shaped pattern of development (Marcus *et al.* 1992).

Different accounts have been given of why this U-shaped learning occurs. The dual-mechanism model assumes that the representation and acquisition of inflectional morphology involves two separate mechanisms: a rote-learning mechanism for irregular forms and a symbolic rule system which handles regular inflections (Marcus *et al.* 1992, Marcus, Brinkmann, Clahsen, Wiese & Pinker 1995, Pinker 1991). Initially, the child learns regular and irregular forms by the rote-learning mechanism. This is superseded by the rule-system whereby the child realizes that most English verbs and nouns take regular inflections and establishes rules of verb stem + past tense suffix, and noun stem + plural suffix. Overregularization errors occur when the rules are first established. Finally, both processing systems underly the child's and adult's knowledge of inflectional morphology. The rule system is productive and can be extended to nonce forms without relying on lexical entries in memory. The other is a store of irregular forms in lexical memory which is used for processing irregular forms. It is when this system fails to block the rule system that errors of overgeneralization occur (Marcus *et al.* 1992, 1995, Pinker 1999).

Connectionist neural network approaches assume that a single learning mechanism underlies the acquisition of regular and irregular inflections (Plunkett & Marchman 1993, Rumelhart & McClelland 1986). In such models, type and token frequencies of input items and the defining properties of a morphological pattern, i.e., phonological and/or semantic regularities, are the basis for generalization. In a series of simulations Plunkett & Marchman (1993) have shown that a multi-layered perceptron network can learn to map English verb stems to past tense forms by using a single backpropagation learning algorithm. Using an incremental training procedure in terms of quantitative changes in type and token input, the network makes a transition from rote learning of past tense forms to a systematic treatment of past tense formation and applies the regularities constructed to new forms. The system's reorganization is dependent on frequencies of regular and irregular verbs in the input and on increases in vocabulary size. In generalizing, the network uses the regular pattern as well as phonological similarities of subgroups of irregular verbs. Its behaviour resembles that of children learning the English past tense. Using a much larger vocabulary input Plunkett & Juola (1999) have shown that a single unified network can learn past tense and noun plural inflections of English, displaying characteristic U-shaped routes of acquisition and

TABLE 1. *Plural markings on nouns in German*

Suffix	Example	
	Singular	Plural
-(*e*)*n*	*blume*	*blume-n* (flowers)
	bär	*bär-en* (bears)
-*e*	*hund*	*hund-e* (dogs)
Umlaut*+-*e*	*baum*	*bäum-e* (trees)
-*er*	*kind*	*kind-er* (children)
Umlaut+-*er*	*buch*	*büch-er* (books)
-*ø*	*tiger*	*tiger* (tigers)
Umlaut+-*ø*	*mutter*	*mütter* (mothers)
-*s*	*auto*	*auto-s* (cars)

* vowel change

errors similar to those of children. Learning is dependent on a critical mass of vocabulary. These simulations demonstrate that single mechanism models can account for the learning of inflectional morphology (Plunkett & Juola 1999, Plunkett & Marchman 1993).

How do such models apply to inflectional systems which are not so readily characterized as regular and irregular, but display several regularities? According to descriptive analyses, the German noun plural system is of this kind (Augst 1979, Duden 1995, Köpcke 1988, Mugdan 1977, Wurzel 1984). German noun plurals are formed by five different suffixes, -(*e*)*n*, -*e* (schwa), -*ø* (zero marking), -*er*, and -*s* (see Table 1). Three of these, -*e*, -*ø*, and -*er* may combine with a vowel change (Umlaut) of the root, thus rendering 8 different types of plural marking (Augst 1979, Köpcke 1988, Mugdan 1977, Wurzel 1984). The -*n* and -*e* plurals are the most frequent, but exact counts of adult language vary largely: 53–68% for -*n*, 22–33% for -*e*, and 2–8% for the -*er* and -*s* suffixes (Clahsen 1999). Regularities in the application of the different plural markers are based on co-occurrence of gender and/or phonological patterns in word endings (see Table 2). The regularities can be summarized as follows. Feminine and masculine nouns ending in -*e* (schwa) take the -*n* plural. Most masculine and most neuter nouns take the -*e* plural allomorph, but some take -*er*. Masculine and neuter nouns ending in -*er*, -*el*, -*en* -*chen* and -*lein* always take -*ø* plural. Nouns ending in an unstressed vowel other than schwa or diphthong take -*s*, as well as plurals of names, and loan words, which are mostly

TABLE 2. *Regularities of the German plural marking system: assignment of nouns to plural markers*

Suffix	Nouns assigned on the basis of word endings, rule-like[a] with few exceptions	Nouns assigned on the basis of probabilistic regularities,[a] independent of word ending	Plural marker: Suffix + Umlaut, if possible[b]
-(*e*)*n*	fem. and masc. nouns ending in -*e* (schwa)[c]	fem. nouns (73%) masc. nouns (9%) neuter nouns (4%)	
-*e*		masc. nouns (89%) neuter nouns (74%) fem. nouns (25%)	Umlaut+-*e*: often for masc. nouns sometimes for neuter nouns always for fem. nouns
-*er*		neuter nouns (21%) masc. nouns (2%)	Umlaut+-*er*: always
-*ø*	masc. and neuter nouns ending in: -*er*, -*en*, -*el*, -*chen*, -*lein*[c]		Umlaut+-*ø*: sometimes
-*s*	words ending in an unstressed vowel or diphthong, family names, words from English or French		

[a] Categories according to Duden (1995).
[b] Umlaut is possible for the vowels *a*, *o*, *u*, and the diphthong *au*.
[c] Includes only endings which are relevant for words in small children's vocabularies.

nouns from English and French. Where the vowel allows Umlaut (vowel change), it must occur for the *-er* suffix and can occur for *-e* and *-ø* suffixes. The German plural system is a system with multiple regularities. Some regularities depend on word endings and are almost deterministic, but contain some exceptions which may be characterized as irregular forms; other regularities are probabilistic (for more details see Tables 1 and 2).

A connectionist neural network should be able to handle such a system, as input frequencies and the defining properties of the regularities – no matter whether they are of a probabilistic or deterministic nature – are the basis of a network's generalizations (Elman, Bates, Johnson, Karmiloff-Smith, Parisi & Plunkett 1996, MacWhinney 1987, Plunkett & Marchman, 1993). A dual mechanism model, however, would have to specify what is regular and irregular in the system. Some investigators (Clahsen 1999, Clahsen, Rothweiler, Woest & Marcus 1992, Marcus *et al.* 1995) have applied the regular/irregular dualism to the German plural system. Despite its low frequency of occurrence, they classify the *-s* plural as default and regular plural, and all other plural markings as irregular. In support of their view they cite evidence from one child who uses the *-s* suffix most frequently in spontaneous errors of overgeneralization (Clahsen *et al.* 1992, Marcus *et al.* 1995) and results from experiments with nonce words. In these experiments native adult speakers were asked to give naturalness judgements of 12 nonce word plurals which rhymed with real German words, and 12 nonce words which were non-rhymes. From each list a third of the words was introduced as new root words, names or borrowings. Results indicated that when nonce words where introduced as new root words, -*s* plurals were judged less natural than irregular plurals in the rhyme condition, but were judged more natural in the non-rhyme condition, although not significantly so in comparison with irregulars. When introduced as borrowings there was no difference between naturalness judgement for both types of plurals, and when introduced as names *-s* plurals were judged more natural than irregular plurals, irrespective of rhyme or non-rhyme condition. Marcus *et al.* (1995) and Clahsen (1999) interpret these results as evidence for the greater naturalness of the *-s* suffix for unusual sounding words, and therefore for its status as the regular German plural form. Bartke (1998) performed the same experiments with children aged 3;1 to 8;10; results showed a statistically non-significant trend for an *s*-preference when nonce words were introduced as new roots in the non-rhyme condition, and a significant preference for -s when nonce words were introduced as names. According to Clahsen (1999) these results demonstrate that the dual structure of regular and irregular plurals is established early in children.

However, alternative interpretations are possible and preferable, given the overall weak tendencies for an *-s* preference in nonce words that are actually displayed in the data (see also Hahn 1999, Indefrey 1999). Indeed, judging *-s* more natural for names or loan words is exactly in accordance with the defining properties of the use of *-s* in German plural formation (see Table 2). Thus, in the experiments of Marcus *et al.* (1995) and Bartke (1998), subjects applied the regularities for the use of *-s* affixation in German plural formation. Furthermore, the reduced naturalness judgements for *-s* in the rhyme condition may have been partly due to the particular rhyme stimuli used in the experiments (see Appendix 3 in Marcus *et al.* 1995). The stimuli did not allow for the *-s* allomorph to sound natural, as no stimulus ended in an unstressed vowel, which is the phonological environment requiring *-s* in German.

For German, the discussion on the acquisition of plural inflections in children focuses largely on cross-sectional experimental data from elicitation studies with children aged between 3 and 11 years. Results of these studies vary widely. A large rate of no marking and a preponderance of overgeneralizations of *-n* and *-e* when nonce words were used are reported (MacWhinney 1978, Mugdan 1977, Schöler, Fromm & Kany 1998). These results are discussed in terms of the difficulties young children experience with the experimental conditions (Mugdan 1977), frequency, and noun gender effects (MacWhinney 1978, Schöler *et al.* 1998). Some studies used a narrowly selected range of stimuli (Bartke 1998, Ewers 1999). Ewers (1999) found that children 3–5 years old overgeneralized *-n* or *-s* less frequently for words with a singular ending in *-en* as opposed to *-er* and *-el*, which is explained by the fact that *-en* is a plural allomorph besides being a singular noun ending. Bartke (1998) found that *-s* overgeneralizations were the most frequent errors when plurals were elicited for low frequency real words. However, the stimuli requiring *-s* included *auto* (car) and *bonbon* (sweet), which may reasonably be assumed to have high frequencies in child language, and this may have influenced the results. It seems likely that the differing results of these elicitation experiments are due to different experimental stimuli, different task instructions, and differing ages of the children.

Spontaneous speech data of the acquisition of German noun plurals are rare. Stern & Stern (1928) report correct use of some plural forms by their children from age 2;0. Park (1978) reports that the two children he studied started using plurals when their MLU was 2.75, and that at higher MLU levels about 90% of plurals were used correctly. The most frequent overgeneralizations in spontaneous speech are reported for *-n*, usually in the form of double-markings, e.g., *pferd-e-n* instead of *pferd-e* (horses), but *-e* and *-s* are also overgeneralized, and errors also involve Umlaut (Gawlitzek-Maiwald 1994, Park 1978). Studying errors in the spontaneous speech of four children Gawlitzek-Maiwald (1994) reports individual preferences for either the *-s* or *-n* error. None of the studies present quantitative analyses based on large numbers of speech samples collected at regular intervals for sufficient numbers of children. Thus, the developmental course of German plural acquisition is not yet understood. Some authors (Bartke 1998, Clahsen 1999, Ewers 1999) equate children's performance in cross-sectional elicitation experiments with acquisition. From a developmental viewpoint, however, such an intepretation may be too far-reaching as most of the children in these experiments were beyond the age of early grammatical learning, and a cross-check with acquisitional data based on spontaneous speech is lacking.

It is the aim of the present study to delineate the course of acquisition of noun plurals by German-speaking children on the basis of extensive longitudinal data from spontaneous speech. Such comprehensive data have not been available so far, but can make a valuable contribution to the current discussion about German noun plurals. The view taken here is that an account of German noun plural acquisition should be based on longitudinal frequency and error data, as both sources are needed for adequate inferences about generalization and learning. An analysis of plural use in parental language will be included because, to date, information on plural use in child-directed speech has been based on only a small number of speech samples (Wagner 1985).

In accordance with a connectionist and emergentist viewpoint (Elman *et al.* 1996, MacWhinney 1987, Plunkett & Marchman 1993), I assume that in acquiring the German plural marking system children make use of distributional and frequency information given in the input language. They will use probabilistic information contained in co-occurrence relationships between phonological patterns of noun endings and plural allomorphs, as well as in the co-occurrence of articles coding for gender and plural allomorphs. Such morphological learning is seen to be based on a sensitivity to statistical patterns in the input language which allows the discovery of recurrent structural patterns. On an analytic level this may be similar to the detection of transitional probabilities between adjacent phonemes observed in 8-month-old babies (Saffran, Aslin & Newport 1996). Further, children will make use of frequencies of occurrence of the different plural markings in adult input language. Rather than starting by rote learning, it is assumed here that children will start generalizing and constructing the different regularities of German plural marking from the beginning. In acquiring a system based on multiple regularities, such a developmental path is seen to be better adapted to the final state of the system than a path from rote learning to rule-based learning. Several predictions follow from these assumptions. Firstly, growth rates of the different plural classes will be in accordance with frequencies of plurals per class in adult input language, with markedly faster growth rates for the most frequent plural forms of the *-n* and *-e* classes. Secondly, it is predicted that errors occur from early on – rather than after an initial period of correct use – and that they reflect the regularities of the German plural marking system. Finally, it is of interest to find out if children use plural classes with the same frequencies as adults. Differences in frequencies of the different classes may be less pronounced because children use basic vocabulary, and in basic German vocabulary the different plurals are more evenly distributed (Augst 1979, Duden 1995, Mugdan 1977).

METHOD

Participants

Participants were 22 children, 12 girls and 10 boys, who took part in a large longitudinal study of language acquisition in German-speaking children with normal hearing and in hearing-impaired children with cochlear implants (Szagun 2000*a*, 2000*b*). The children are resident in Oldenburg, northern Germany, and are growing up in monolingual environments. No child had a diagnosed developmental delay. At age 1;4 when data recording started, children's object permanence scores were on the 5th or 6th stage according to the Infant Psychological Development Scales (German version by Sarimski 1987), thus demonstrating age-appropriate cognitive levels. The children were recruited for the study from three paediatricians' practices and two daycare centres in Oldenburg. Leaflets introducing the study were distributed to parents, and those interested in participation contacted a member of the research group.

Design

A longitudinal study was conducted for the period of 1;4 to 2;10 with 22 children and of 1;4 to 3;8 with a subgroup of 6 children. Two hours' spontaneous speech samples were collected in a free play situation with the child, a parent and an investigator. Here, the focus will be on the subgroup of 6 children, as a large number of speech samples is required for analysing noun plurals. The 6 children, 4 girls and 2 boys, were recorded every 5–6 weeks between ages 1;4 and 3;8; this produced 22 speech samples per child. For the total sample of children and within the context of a comparison with hearing-impaired children (Szagun 2000*a*, 2000*b*) speech samples were collected about every 20 weeks over a period of 18 months at ages 1;4, 1;8, 2;1, 2;5 and 2;10, producing 5 speech samples per child. Children's initial MLUs were ≤ 1.25, with a mean of 1.05 (SD 0.08, range 1.0–1.23). Vocabularies ranged between 0 and 88 words (mean 17.5, SD 19.4), as assessed by parental report using a preliminary German adaptation of the MacArthur Communicative Development Inventory (Fenson, Dale, Reznick, Bates, Thal, & Pethick 1994). At 4 data points – ages 1;4, 1;8, 2;1 and 2;5 – parents' child-directed speech was analysed. Parents were not informed that some of their speech would be used for analysis because it was felt that this might influence their language use.

Data collection, transcription and coding

Data collection took place in a playroom at the University of Oldenburg. The situation was free play, and a parent and a female investigator were present and played with the child. The parent was usually the mother, but for two children out of the total sample it was the father. The investigator left the room for some of the time. The same investigator was assigned to one child throughout the period of data collection. Toys from which children could choose were: cars and garage, dolls, doll's house, zoo animals, farm animals, forest animals, children's picture books, puzzles, medical kit, ambulance, fire-station. Recording was by digital auditory tape recording (DAT), using portable Sony DAT-recorders and highly sensitive Sony or Aiwa microphones. Video recordings were also made.

Everything spoken by the child and the first 500 parental utterances at the relevant data points (see *Design*) were transcribed using the CHILDES system (MacWhinney 1995). Rules for transcribing contracted speech, coding grammatical morphemes and MLU were adapted to German (Szagun 1999). Rules for transcribing contracted speech concern the orthography for shortened forms of spoken German, e.g., the shortening of *ist* (English 'is') to *is*, or *nicht* (not) to *nich*, or *du* (you) to *de*, and also involve rules for writing contractions of spoken German, e.g., contracting an infinitive such as *drehen* (turn) to *dreh'n* or *hast du* (have you) to *hast'e*. For noun plurals, such contractions involve the dropping of the schwa sound for plurals ending in *-en* when the suffix occurs after nasals or liquids, for instance, *blum'n* for *blumen* (flowers) or *baer'n* for *baeren* (bears) where /n/ is syllabic in a two-syllable word. The rules are an equivalent for German to rules laid down by MacWhinney (1995) for American English. They are spelled out in detail by Szagun (1999).

Transcription was done from the DAT recordings using videotapes for contextual information. One researcher and 7 graduate students carried out the transcriptions. All were trained extensively on using CHAT notations and the transcription rules. After 10 training sessions 8 different combinations of pairs of transcribers transcribed a new set of 100 utterances. Agreements between the 8 pairs ranged from 96% to 100%. Noun plurals were coded as part of the overall coding of MLU and morphology (see Szagun 2000*a*) which was done by 3 researchers. Reliability checks were performed on 20% on the transcripts. Cohen's kappa was calculated 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. There were no disagreements with respect to coding of plurals. Plurals with *-ø* marking were counted only if the use of a plural determiner and/or congruence of the verb indicated plurality and both coders agreed.

RESULTS

Course of acquisition

The course of acquisition of plural forms is analysed on the basis of 22 speech samples per child from 6 children (1;4 to 3;8). The number of linguistic utterances per speech sample ranged between a mean of 136 (SD 100.2, range 5–261) for the data point with the least number of utterances and a mean of 1039 (SD 249, range 722–1372) for the data point with the largest number of utterances. All plurals, correct and erroneous, were extracted from these speech samples. Plurals were in the case categories of nominative (71%), accusative (25%) and dative (4%). Nominative and accusative are formally identical, dative adds an *-n* in the *-e* and *-er* plural paradigm. Case marking is not relevant for the present analyses and so is not taken into account. Plurals are not marked for gender in German. For the present analyses, type rather than token use is of interest, because type use is indicative of generalization. In presenting the data per individual child, abbreviations of a child's first name are used. Parental consent for this use was obtained. ANA, EME, LIS and RAH are girls, and FAL and SOE are boys.

Growth of plurals per individual child Cumulative numbers of correct plurals (types) were calculated per individual child. Functions were

TABLE 3. *Summary statistics for curve estimation models for individual growth curves of plural types*

Child	Method	R^2	d.f.	F	Significance	b_1	b_2
FAL	linear	0.82	18	85.6	0.001	2.16	
	quadratic	0.99	17	5044.1	0.001	−2.93	0.15
ANA	linear	0.85	19	112.8	0.001	1.77	
	quadratic	0.99	18	4278.4	0.001	−1.79	0.10
RAH	linear	0.86	17	110.5	0.001	1.65	
	quadratic	0.99	16	1001.9	0.001	−1.87	0.10
SOE	linear	0.90	20	183.0	0.001	2.04	
	quadratic	0.99	19	1209.1	0.001	−1.02	0.09
LIS	linear	0.85	21	121.9	0.001	1.29	
	quadratic	0.99	20	1502.7	0.001	−1.09	0.07
EME	linear	0.77	11	36.9	0.001	1.04	
	quadratic	0.99	10	1462.1	0.001	−3.64	0.12

fitted to each individual growth curve using SPSS curve estimation procedures. Summary stastistics for curve estimation models are presented in Table 3, and fitted and observed values are shown in Fig. 1. For each child there is a significant linear and quadratic trend in the data (see Table 3). The b_1 coefficient indicates the increase – or growth – rate for the linear trend, and the b_2 coefficient the additional change in increase rate due to the quadratic trend. The increase in R^2 indicates the better fit of the model to the data by adding the quadratic term. As indicated by b_1 and b_2 coefficients, FAL has the most rapid growth rate of plural types, followed by RAH and ANA whose growth rates are very similar to each other but well below FAL's. For SOE the quadratic trend adds less to R^2 when compared with the other children, and his growth curve has the best linear fit. This is reflected in more rapid increase at the early age levels but less acceleration later on (Fig. 1). LIS who starts using plurals earliest has the slowest growth rate, both in terms of a low linear increase rate and a low additional quadratic change rate. EME starts by using plurals much later than the other children. While increase rate is low in terms of linear growth, the quadratic term adds substantially, as reflected in R^2 and b_2, and growth rate accelerates strongly over time (Fig. 1 and Table 3).

Growth of different plural classes In order to examine the increase in plurals per plural marking, cumulative frequencies of plural types per plural class as used by the children were calculated. As the different

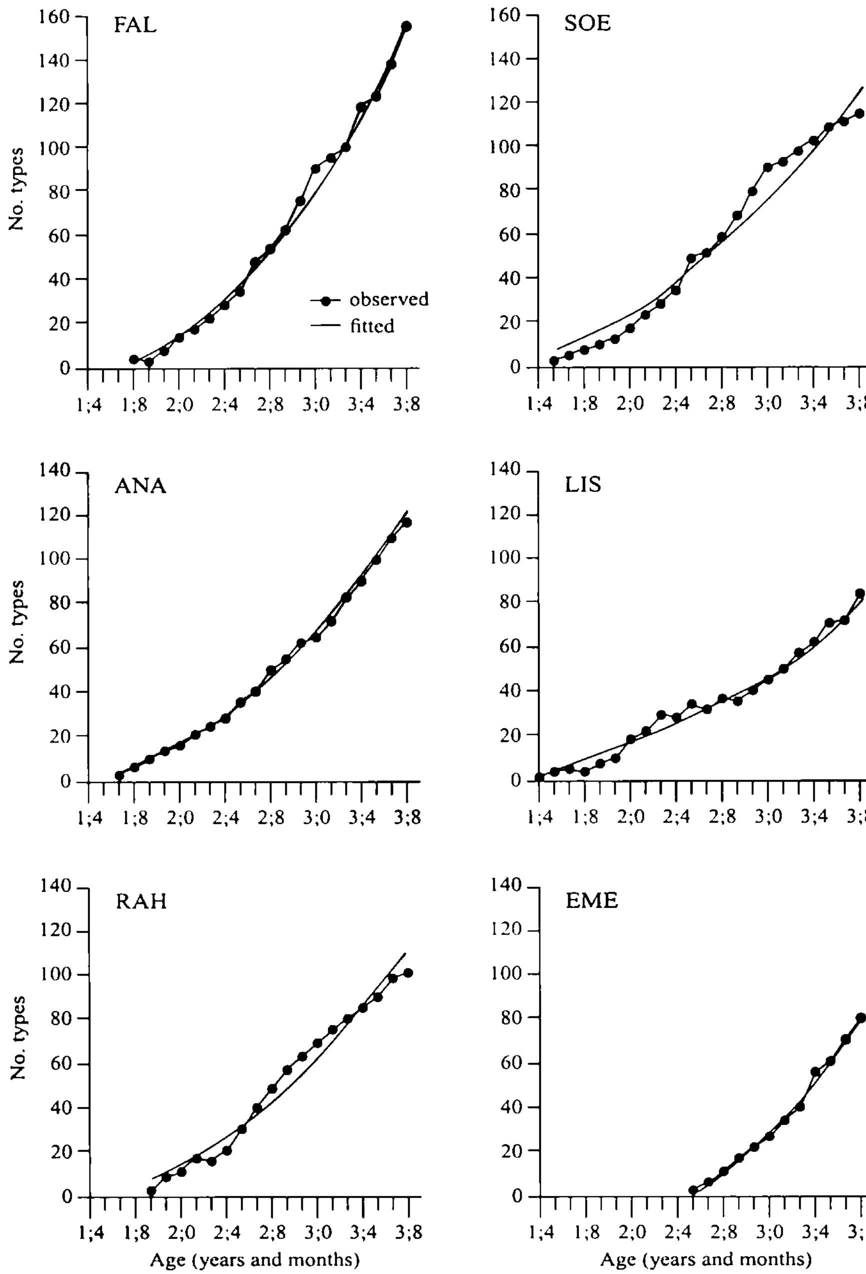

Fig. 1. Growth patterns of plurals over age per individual child with observed cumulative type frequencies and fitted values

TABLE 4. *Summary statistics for curve estimation models for growth curves of group means of different plural classes*

Child	Method	R2	d.f.	F	Significance	b_1	b_2
-n	linear	0.82	18	82.3	0.001	0.58	
	quadratic	0.99	17	4655.1	0.001	−0.81	0.04
-e	linear	0.90	18	161.4	0.001	0.40	
	quadratic	0.99	17	3330.3	0.001	−0.28	0.02
-ø	linear	0.70	18	41.9	0.001	0.15	
	quadratic	0.98	17	457.5	0.001	−0.35	0.014
Umlaut+*-e*	linear	0.88	18	134.1	0.001	0.20	
	quadratic	0.98	17	639.0	0.001	−0.16	0.01
-s	linear	0.87	18	129.6	0.001	0.10	
	quadratic	0.99	17	3884.5	0.001	−0.09	0.0057
Umlaut+*-er*	linear	0.91	18	182.5	0.001	0.12	
	quadratic	0.98	17	698.5	0.001	−0.06	0.0054
-er	linear	0.91	18	198.5	0.001	0.06	
	quadratic	0.98	17	673.4	0.001	−0.03	0.003
Umlaut+*-ø*	linear	0.94	18	283.9	0.001	0.03	
	quadratic	0.97	17	307.2	0.001	−0.001	0.001

plural classes display similar sequential onset per individual child, an analysis for the group of 6 children was performed. Age 1;8 was chosen as a starting point, because by that time 4 of the 6 children were using plurals with the 5th child following at 1;9, and 6 of the 8 plural patterns had begun to be used. Figure 2 presents mean cumulative type frequencies for each of the 8 plural markings over age averaged for the 6 children. Mean values were fitted to functions, and summary statistics for curve estimation models are presented in Table 4. For each plural pattern there is a significant linear and quadratic trend (see Table 4). As indicated by b_1 and b_2 coefficients, growth rate is highest for *-n* plurals, followed by plurals with *-e*, *-ø*, and Umlaut+*-e*. The *-s* class has a slightly higher growth rate than Umlaut+*-er*, because of its larger quadratic term, and plurals with *-er* and Umlaut+*-ø* have the slowest growth rates (Fig. 2). The change in growth rate due to the quadratic term is strongest for *-ø* plurals and fairly substantial for *-n* and *-s* plurals while it is only slight for most of the plural classes (see Table 4 for R^2).

The next question is: do growth rates of the different plural classes differ significantly from one another at different points in time? In

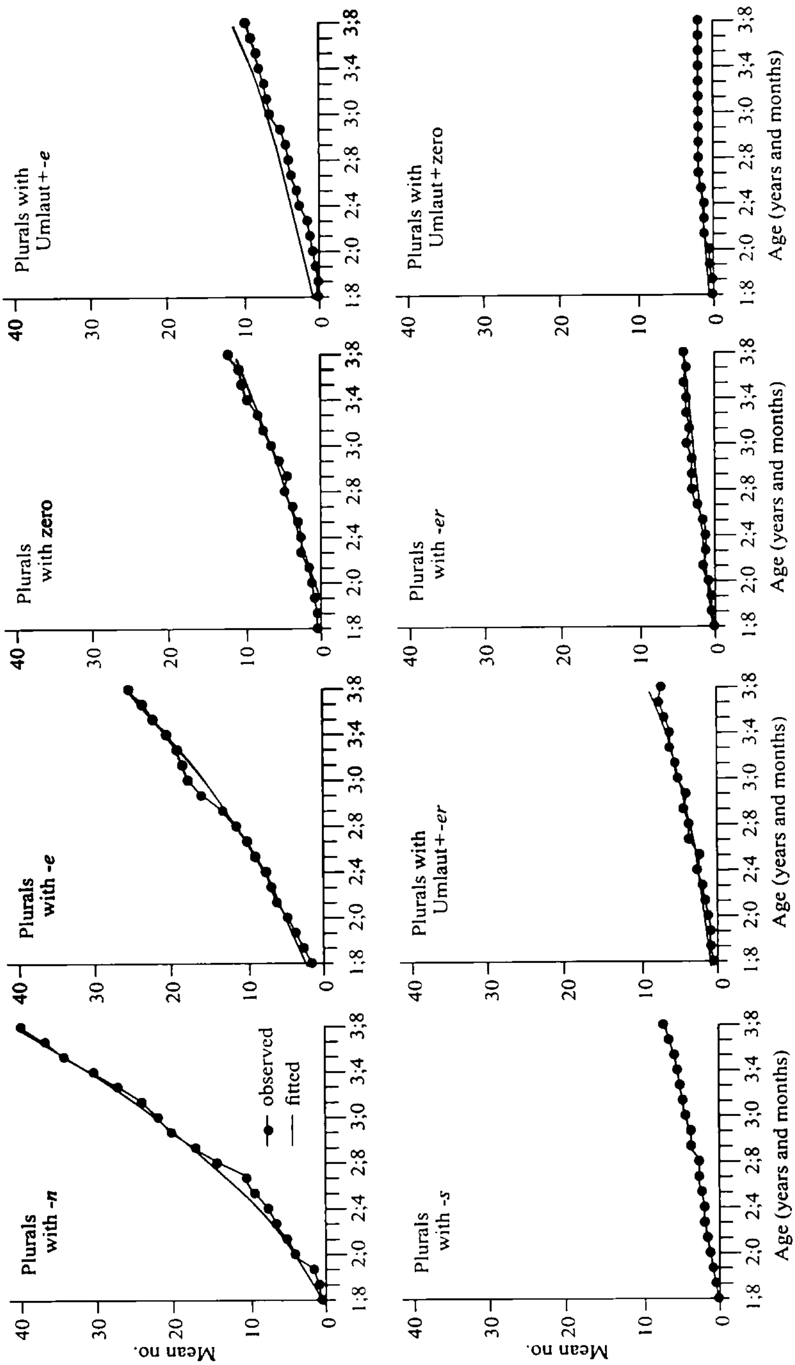

Fig. 2. Growth patterns of different plural markings over age with means for observed cumulative type frequencies per plural marker and fitted values

order to use growth rates for inferential statistical analysis, functions were fitted to the data per child and per plural pattern. The parameters of curve fitting, b_1 and b_2, were used for calculating growth rates per child, plural class and time point, growth rate or increase rate being identical to the first derivative of a function at a particular time point. For the combined linear and quadratic trends the first derivative for a particular time point was calculated using the equation $y' = b_1 + b_2 \times t$, where b_1 and b_2 are the regression coefficients and t stands for time (data) point. In the case of a linear fit, the first derivative is identical to b_1. Growth rates were compared at 4 data points, age levels 1;8, 2;4, 3;0 and 3;8, and for the 4 plural classes which look maximally different *-n*, *-e*, *-ø*, and *-er* (Fig. 2). Number of repeated measures, i.e., data points and plural classes, was restricted because of the low number of subjects (N = 6). A two-way ANOVA with repeated measures on plural class (4) and time (4) was computed. There was a significant main effect of plural pattern ($F(3,7) = 100.94$, $p < 0.001$), using the Greenhouse-Geisser adjustment, a significant main effect of time ($F(3,15) = 23.56$, $p < 0.001$, and a significant class × time interaction ($F(9,45) = 17.75$, $p < 0.001$). Concerning follow-up tests, the difference between growth rates of different plural classes at each time point is of interest. There were no differences at 1;8. From 2;4 growth rate of *-n* plurals exceeded that of any other class significantly (Tukey's HSD test for repeated measures, $p < 0.05$ (Gravetter & Wallnau 1996). At 3;0 and 3;8 growth of *-e* plurals exceeded that of *-er* plurals significantly, and finally at 3;8 growth rate of *-ø* plurals exceeded that of *-er* plurals significantly (Tukey's, $p < 0.05$). Thus, growth of the different plural forms diverges over age. If we extend the analysis by analogy to similar-looking growth curves (see Fig. 2), we can say that from 3;0 *e*-plurals grow significantly faster than *-er*, Umlaut+*-er*, *-s* and Umlaut+*-ø* plurals, and at 3;8 this is also true of plurals with *-ø* and plurals with Umlaut+*-e*.

Child and adult use of plurals In order to compare child and adult use of plurals, relative type frequencies per plural class out of the total number of plurals were calculated. For children this was done for cumulative type frequencies at two age levels, 2;10 and 3;8. Age 2;10 was chosen because overall frequencies of plural types are high enough to make counts of relative frequencies with 8 different categories meaningful, and because at this age level data from another 16 children, i.e., a larger sample, are available. Age level 3;8 was chosen because it is the final age level. The database for adult plural use contains 2000 parental utterances at 4 data points (children's ages 1;4, 1;8, 2;1 and 2;5), with 500 utterances per data point. There were no

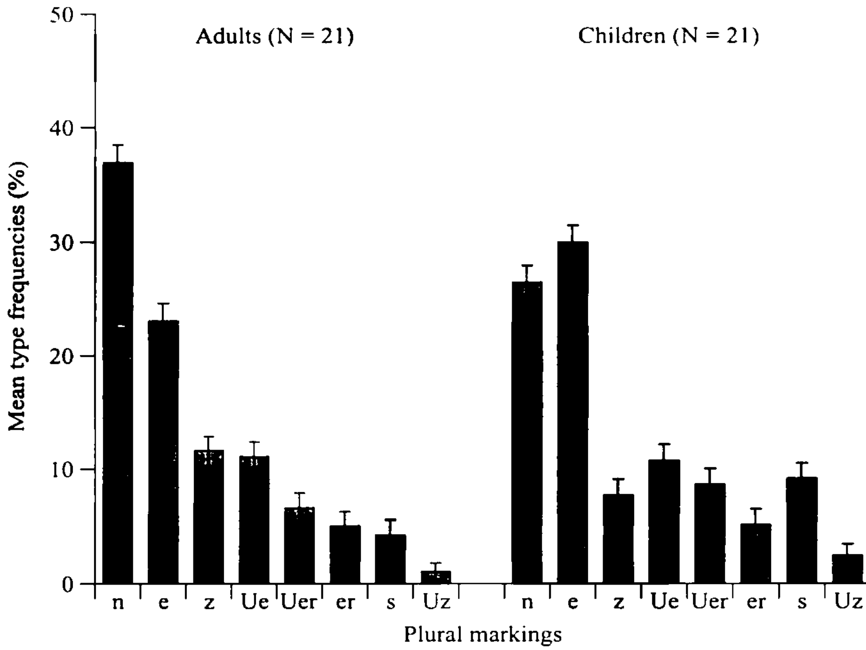

Fig. 3. Mean relative cumulative frequencies (with standard error bars) for types per plural marker for adults and for children at age 2;10 (key: Ue = Umlaut+-*e*, Uer = Umlaut+-*er*, z = zero marking, Uz = Umlaut+zero marking)

differences in use of plural classes per data point, and data were collapsed representing adult child-directed speech. For 20 children parental speech is the mother's speech, and for 2 children it is the father's.

First, adult relative frequencies were compared with child cumulative relative frequencies at age 2;10 on the basis of data from 21 children, with 5 speech samples per child, and 21 adults. (One child produced too few plurals to make relative frequency counts meaningful, so his and the corresponding parent's data were dropped from the analysis.) A two-way ANOVA with repeated measures on plural class (8) and group as between subjects-factor (2) was computed using an arcsine transformation on relative frequency scores. There was a significant main effect of plural class ($F(3,123) = 94.65$, $p < 0.001$, and a significant plural class × group interaction ($F(3,123) = 5.41$, $p < 0.001$, Greenhouse-Geisser adjustment). Figure 3 presents mean relative type frequencies per plural class. Comparing adjacent classes per group showed that for adults *-n*, *-e* and *-ø* plurals differed signficantly in decreasing order ($p < 0.01$, Scheffé test for repeated measures, Gravetter & Wallnau 1996). For children, on the other hand, relative frequencies of *-n* and *-e* plurals did not differ, but *-n* plurals were significantly more frequent than adjacent Umlaut+*-e* plurals ($p < 0.1$, Scheffé test for repeated measures). There were significant differences between groups. Adults used significantly more *-n* and *-ø* plurals than children, and children used significantly more *-e* and *-s* plurals than adults ($p < 0.01$, Scheffé test).

Next, adults were compared with children at age 3;8. Data from 6 children are available beyond age 2;10, and cumulative frequencies of plurals for the analysis are based on 22 speech samples per child. The database for adults is the same as in the previous analysis, except that data from only 6 subjects, the corresponding 6 parents, are used. These 6 parents did not differ from the 15 other parents used in the previous analysis. A two-way ANOVA, plural class (8, repeated measures) × group (2) was computed, again using an arcsine transformation on relative frequency scores. There was a significant main effect of plural class ($F(2,15) = 49.38$, $p < 0.001$, using the Greenhouse-Geisser adjustment). There was no significant main effect of group and no significant plural class × group interaction. Thus, at 3;8 child frequencies of plural patterns did not differ from adult frequencies. Means for the combined groups are depicted in Fig. 4. Differences between adjacent plural classes were significant for *-n* versus *-e*, and *-e* versus *-ø* plurals, in decreasing order ($p < 0.05$, Scheffé test for repeated measures). To check whether the observed different frequencies for the child groups are a true age effect or due to sample size or number of speech samples, i.e., number of plurals sampled, the appropriate comparisons were performed at age 2;10. For the 6 children of the subsample, cumulative relative frequencies were compared on the basis of 15 speech samples (all data points) and of 5 speech samples (the major data points used for all 21 children, see *Design*). There was no difference. Also, when assessed on the basis of 5 speech samples, the 6 children of the subsample did not differ from the other 15 children of the total sample. Thus, the observed differences in use of plural classes are due to age.

Errors

Figure 5 presents mean frequencies of errors (%) out of the total of correct + erroneous plural forms for types per data point. From 1;9 to

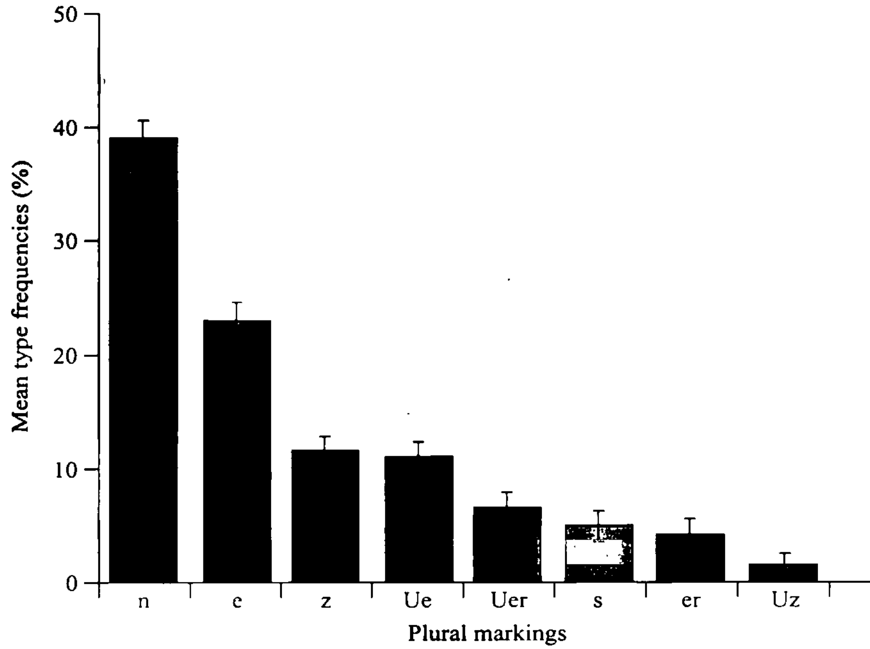

Fig. 4. Mean relative cumulative frequencies (with standard error bars) for types per plural marker for adults and children at age 3;8 collapsed (for key, see Fig. 3)

2;4 means are over 5 children, and from 2;5 over 6 children. Error rates ranged between 3% and 16%. Error rates were fairly high, and children produced errors almost right from the beginning of using plural forms. An examination of individual children rendered similar results. RAH started by using correct and incorrect plurals simultaneously. For EME and FAL the gap between the first correct and first incorrect use of plural forms was 2 data points, i.e., 10 weeks. For LIS and SOE it was 3 and 4 data points, i.e., 15 and 20 weeks, respectively. The maximum time gap between first correct and incorrect use of plural forms was 5 data points (around 27 weeks) for ANA. The average time gap was 3.7 data points, or around 18 weeks. The children's phonological systems were sufficiently advanced to allow marking for plurality. This also applied to EME who was a late talker and did not start using plurals till 2;5.

Exloring errors further, a qualitative analysis of errors was performed. Errors were classified according to the following criteria: (a) which type

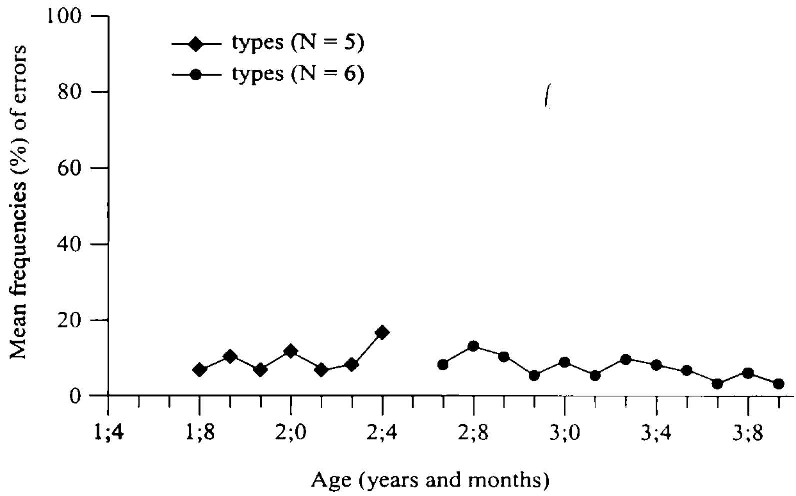

Fig. 5. Mean frequencies (%) of errors over age

of erroneous marking was used, i.e., wrong suffix and which one, partial marking, or no marking, and (b) which type of plural marking it replaced or was added to. Error categories were distinguished as described below. They are also presented in Table 5, as they combine with plural patterns, and with additional examples.

(1) Affixing *-n*: the suffix *-n* is affixed to a form already correctly marked for plural or not. Affixation of *-n* occurred to *-e*, e.g., *die hund-e-n* (correct: *hund-e*, 'dogs') and in a *-ø* marking context. For the *-e* context it is not clear whether *-n* is added to *-e* or *-(e)n* substituted for *-e*. For the *-ø* context, it is not clear whether *-n* is added to the singular, affixed to a *-ø* suffix, or substituted for a *-ø* suffix. Addition of *-n* to a correctly marked plural occurred for the following patterns: *-er*, Umlaut+*-er*, Umlaut+*-e*. Examples are: *die kind-er-n* (correct: *kind-er*, 'children'), *die fledermäus-e-n* (correct: *fledermäus-e*, 'bats'). (Erroneous *-n* affixation discussed here did not occur in a dative plural context where *-n* marking would be correct.)

(2) Affixing *-s*: The suffix *-s* is affixed to a form already marked for plural or not. In the case of a *-ø* suffix environment one cannot

TABLE 5. *Error patterns for five error categories with examples*

Error pattern	Example	Correct form	English
1. affixing *-n* to:			
-e	*tier-e-n**	*tier-e*	animals
Umlaut+-*e*	*nüss-e-n*	*nüss-e*	nuts
-er	*kind-er-n*	*kind-er*	children
Umlaut+-*er*	*männ-er-n*	*männ-er*	men
-ø	*tiger-n*	*tiger*	tigers
2. affixing *-s* to:			
-ø	*mülleimer-s*	*mülleimer*	dustbin
-er	*kind-er-s*	*kind-er*	children
Umlaut+-*er*	*männ-er-s*	*männ-er*	men
-n	*nudel-n-s*	*nudel-n*	noodles
3. *-e* instead of:			
-en	*bett-e*	*bett-en*	beds
Umlaut+-*er*	*dach-e*	*däch-er*	roofs
4. *-er* instead of:			
-n	*spielsach-er*	*spielsache-n*	toys
-s	*aut-er*	*autos*	cars
5. partial marking for:			
Umlaut+-*e*	*fuchs-e*	*füchs-e*	foxes
	türm	*türm-e*	towers
Umlaut+-*er*	*huhn-er*	*hühn-er*	chickens

* None of the forms was used as a dative plural for which the *-n* suffix would be correct.

tell whether *-s* is added to the singular or the *-ø* suffix, or substituted for the *-ø* suffix, e.g., *tiger-s* (correct: *tiger*, 'tigers'). Affixation of *-s* occurred for the following markings: *-ø*, Umlaut+-*ø*. Addition of *-s* to a correctly marked form occured for *-n*, *-er*, Umlaut+-*er*, e.g., *knochen-s* (correct: *knochen*, 'bones').

(3) Affixing *-e*: The suffix *-e* is used incorrectly; this occurred instead of *-en* and for Umlaut+-*er*, e.g., *herz-e* (correct: *herz-en*, 'hearts').

(4) Affixing *-er*: The suffix *-er* is used incorrectly; this occurred instead of *-n* and *-s*, e.g., *spielsach-er* (correct: *spielsache-n*, 'toys'), *aut-er* (correct: *auto-s*, 'cars').

(5) Partial marking: Partial marking occurred when there are two elements in plural marking, Umlaut and a suffix, and the children used only one of the elements. It occured for Umlaut+-e and Umlaut+-*er*, e.g., *stuhl-e* (correct: *stühl-e*, 'chairs'), *bäum* (correct: *bäum-e*, 'trees').

(6) No marking: The noun is not marked for plural, although determiner and verb were marked for plurality. No marking occurred for the following patterns: *-e*, Umlaut+-*e*, *-s*, *-n*, Umlaut+-*er*, e.g., *die tier sin' da einsperrt* (the animals are locked in there; correct plural: *tier-e*), *das sin' die auto* (these are the cars; correct plural: *auto-s*). Of course, no marking could be marking by *-ø* suffix; there is no way of telling. But it seems more cautious and therefore preferable to assume lack of marking.

(7) Other: Errors which did not fit into one of the above categories, e.g., *bäuer* (correct: *bauern*, 'farmers').

Two independent coders categorized errors according to the above scheme. As a measure of reliability Cohen's kappa was used. A kappa of 0.96 indicated very good agreement. The category 'other' was 3.1% of total errors.

There were no effects of age in error use. Therefore, results henceforth will be based on analyses collapsed across this factor. Table 6 presents a summary of the number of errors per error category out of the total of errors summed across children, separately for the sample of 6 children with 22 speech samples and a sample of 11 children with 5 speech samples. (In the group of 16 children with 5 speech samples, error scores for 5 children were 0, and they were dropped from the analysis.) Errors in the different categories were fairly evenly distributed, except for the *-e* and *-er* errors which were much less frequent. The *-e* error occurred only in the subsample of 6 children and the *-er* error in the subsample of 11 children. Next, for each child, error scores per error category for types were computed. First, differences between number of errors per error category were tested, irrespective of where the error occurred. One-way ANOVAs were computed with repeated measures on error category, separately for the 6 children with 22 speech samples and the 11 children with 5 speech samples. For the sample of 6 children there was a significant main effect of error category ($F(4,20) = 3.30$, $p < 0.031$). Pairwise comparisons showed that the *-e* error was significantly less frequent than no marking (Tukey's test for repeated measures, $p < 0.05$). No

TABLE 6. *Absolute and relative (%) number of errors per error category out of the total of errors (types) summed across children per sample of 6 children and 11 children*

	Type frequencies per error category (% in brackets)	
Error category	6 children (22 speech samples)	11 children (5 speech samples)
-n	23 (24.2)	9 (27.3)
-s	23 (24.2)	6 (18.2)
-e	3 (3.1)	0 (0)
-er	0 (0)	2 (6.1)
partial marking	15 (15.8)	7 (21.2)
no marking	28 (29.5)	9 (27.3)
other	3 (3.1)	0 (0)
Total	95	33

other comparisons were significant. For the sample of 11 children there was no significant main effect of error category. Thus, frequencies of errors per category did not differ. Mean number of errors per category for the two groups of children are shown in Fig. 6.

When describing error categories a distinction was made between a particular error category, i.e., affixing *-n*, *-s*, *-e* or *-er*, occurring as (a) an addition to a correct plural yielding a double-marking error, or (b) as substitution of a correct plural pattern, or (c) whether the erroneous marking is ambiguous. This categorization cuts across the error categories. Categorization of errors in this way will henceforth be called error types. Table 7 presents a confusion matrix with numbers of errors per error type for error categories by plural patterns. Number of errors are word type frequencies summed across all children, i.e., irrespective of the sample of 6 or 11 children. Numbers in the relevant error categories do not correspond exactly to numbers in Table 6, because some word types were identical in the two samples of children and were only counted once. In the presentation of errors in Table 7 it is assumed that affixing *-n* to *-e* is an error of addition yielding a double-marked form. This is done because the error pattern is seen as equivalent to adding *-n* to Umlaut+*-e*, where the alternative interpretation – substitution of *-(e)n* for *-e* – is not possible. Partial marking is presented as a substitution error, i.e., *-e* substituting Umlaut+*-e*, or Umlaut substituting Umlaut+*-e*, and equivalent for the Umlaut+*-er* pattern. Affixing a suffix where *-ø* or Umlaut+*-ø* would be

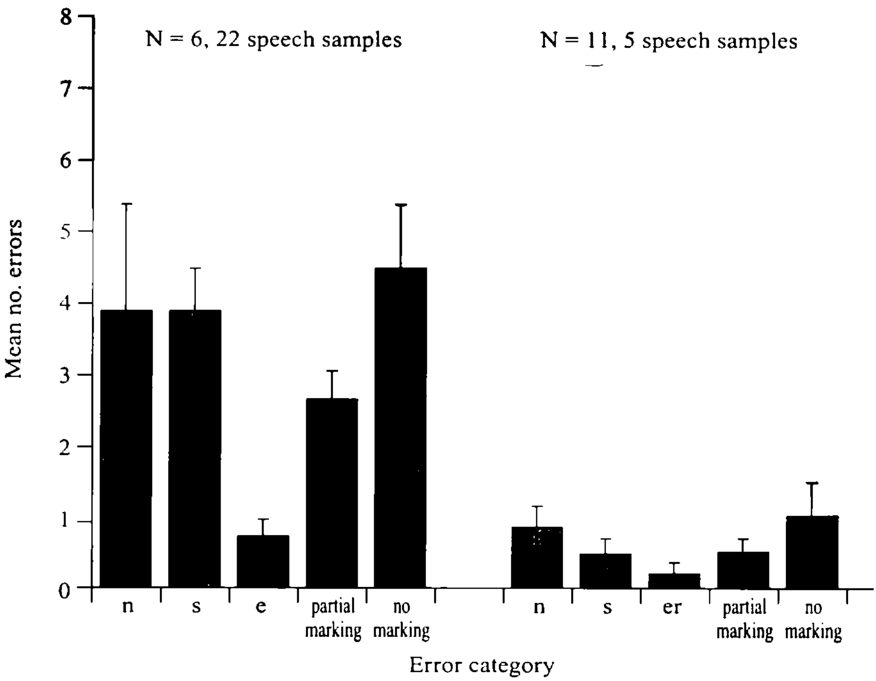

Fig. 6. Mean number of errors (with standard error bars) per error category

correct is treated as ambiguous with respect to addition or substitution. Under these assumptions addition errors yielding double-marking most frequently involve the addition of *-n*, substitution errors most frequently involve Umlaut and the *-e* suffix, and ambiguous errors are more or less restricted to *-s* in a *-ø* plural environment.

To find out if errors are based on the regularities of the German plural marking system, for each error category comparisons were made concerning the frequencies with which different (correct) plural markers were affected by a particular error. As Umlaut errors are captured by the partial marking category, in this analysis only suffix markings are considered, collapsing *-e* and Umlaut+*-e*, *-er* and Umlaut+*-er*, *-ø* and Umlaut+*-ø*. One-way ANOVAs with repeated measures on affected plural marker were computed for the *-n*, *-s*, and no marking error categories, with 3, 3 and 4 levels, respectively. A *t*-test was computed for comparing plurals affected by partial marking.

TABLE 7. *Confusion matrix with number of errors (type frequencies) per error type for plural patterns by error categories out of the total of errors summed across all children*

		Error categories				
Error types	Plural patterns	*-(e)n*	*-s*	*-e*	*-er*	Umlaut*
Addition of an affix to a correct plural form:	*-(e)n*	–	3			
	-s		–			
	-e	11		–		
	Umlaut+*-e*	7				
	-er	2	2		–	
	Umlaut+*-er*	4	1			
Substitution of one plural pattern for another:	*-(e)n*	–	1	3	1	
	-s		–		1	
	-e			–		
	Umlaut+*-e*			9		6
	-er				–	
	Umlaut+*-er*			1	1	2
Ambiguous with respect to addition or substitution:	*-ø*	1	19			
	Umlaut+*-ø*		1			

* Umlaut corresponds to partial marking in this presentation.

For adding *-n* and 'no marking' there were no significant main effects of affected plural marker. For the error pattern of affixing *-s* there was a significant main effect of affected plural marker ($F(2,10) = 11.3$, $p < 0.003$). Pairwise comparisons showed that *-s* was used significantly more frequently in the context of a *-ø* plural than with any other plural marking (Tukey's test for repeated measures, $p < 0.05$). Partial marking occurred significantly more frequently for plurals which involve Umlaut+*-e* than those which involve Umlaut+*-er* ($t(5) = 2.98$, $p < 0.03$). Figure 7 shows mean numbers of errors per affected plural markers within a particular error category.

A closer examination of the nouns incorrectly marked with *-s* revealed that children used *-s* errors differently within the *-ø* plural paradigm. A large majority of nouns affixed with *-s* ended in *-er* in the singular, e.g., *tiger-s* (tigers), *saurier-s* (dinosaurs), *jäger-s* (hunters). In

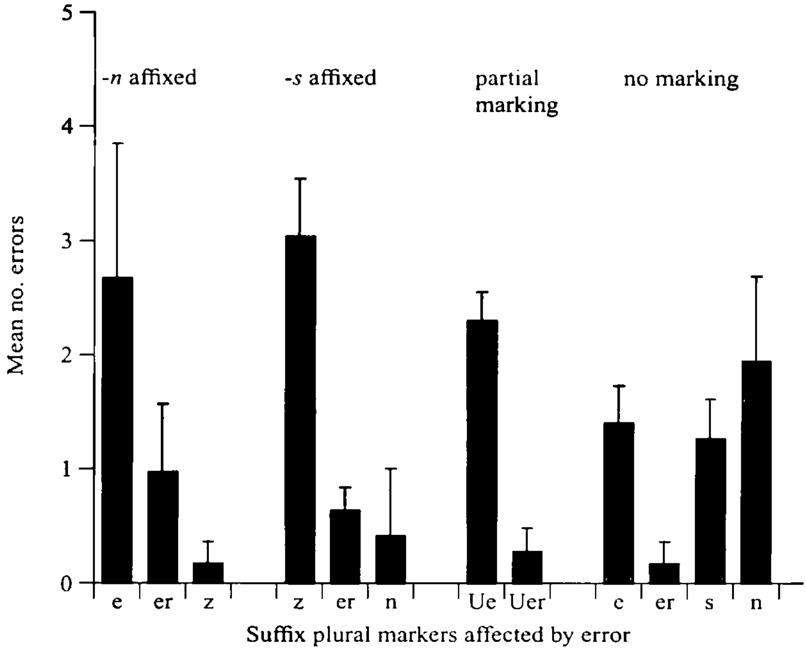

Fig. 7. Mean number of errors (with standard error bars) per plural marker affected within a particular error category

German the final *-er* is pronounced [ɐ], and children may treat it as equivalent to nouns ending in an unstressed vowel, which take *-s* regularly (see Table 2), thus favouring a regular plural marking pattern. To test this hypothesis a comparison of children's *-s* errors occurring on singular nouns ending in *-er*, *-el* or *-en* (the phonological environment requiring *-ø* marking, see Table 2) was performed. A one-way ANOVA with repeated measures (3) on word final pattern rendered a significant main effect of final pattern ($F(2,10) = 13.33$, $p < 0.002$). Pairwise comparisons showed that adding *-s* to final *-er* was significantly more frequent than to final *-en* or *-el* (Tukey's test for repeated measures, $p < 0.05$). Mean numbers of *-s* errors are presented Fig. 8.

Overall, the results show that errors are not arbitrary, but are influenced by the regularities of the German plural marking system. Thus, *-s* is preferred in the context of *-ø* marking and, within this class,

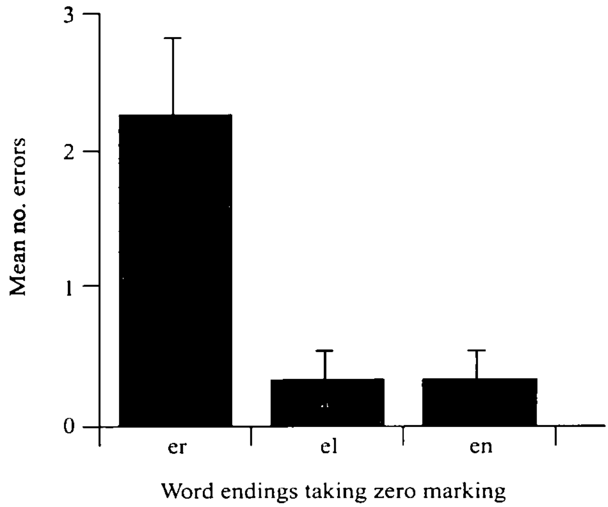

Fig. 8. Mean number of *-s* errors (with standard error bars) per singular word ending

for singulars ending in *-er* (pronounced [ɐ]) partial marking is preferred for words that take Umlaut+*-e*, whereas *-n* and no marking are distributed more evenly.

DISCUSSION

Results show that, overall, onset of plural use was early in children, but growth rates of type frequencies varied between children. Growth rates of the different plural classes differed considerably. Plurals with *-n* displayed the most rapid growth and exceeded all other plural classes significantly from age 2;4. Plurals with *-e*, *-ø*, and Umlaut+*-e* followed next, whereas plurals with *-s*, Umlaut+*-er*, *-er* and Umlaut+*-ø* had considerably slower growth rates. Growth of *-e* plurals exceeded the latter 4 patterns significantly from 3;0, and growth of *-ø* plurals did so at 3;8.

Relative cumulative type frequencies per plural class at ages 2;10 and 3;8 were compared with relative type frequencies in adult speech to children. There were differences between adults and children aged 2;10. Adults used significantly more *-n* and *-ø* plurals than children did, whereas children at 2;10 used significantly more *-e* and *-s* plurals than adults. There were no differences between adults and children at 3;8; *-n* plurals were significantly most frequent, followed by *-e* and *-ø* plurals with significant differences between them. The other plural classes were less frequent, but did not differ significantly. For children at 2;10, however, frequencies of *-n* and *-e* plurals did not differ yet, but both plural classes exceeded all the others significantly.

Children produced errors in plural marking almost from the start, and with high error rates. Error rates did not differ over age. Different types of errors were made, adding *-n* to a form already marked for plural, affixing *-s*, *-e*, *-er*, partial marking, and no marking. There were no significant differences between frequencies of use of the *-n*, *-s*, partial marking, and no marking error types, but the *-e* error occured signficantly less frequently than the no marking error. Errors were not arbitrary, but particular errors were significantly more frequent in the contexts of particular word endings. Thus, the *-s* error was used most frequently when word endings require the *-ø* allomorph, and within this phonological environment most frequently for singular forms ending in *-er*. Partial marking was used more frequently for words requiring Umlaut+*-e* than words requiring Umlaut+*-er*. The use of the *-n* error and no marking was less restricted.

The present results diverge from previous observations on plural use (Gawlitzek-Maiwald 1994, Park 1978, Stern & Stern 1928) in a number of ways. We found that children started using plurals when their MLUs were around 1.25 (Szagun 2000*b*), compared with 2.75 reported by Park (1978). This difference is likely to be due to the comparatively large number of speech samples and utterances per child which were analysed here. Noun plurals do not occur as frequently as, for instance, articles, and a considerable amount of spontaneous speech has to be available to sample plural use adequately.

The present results diverge from frequency counts of the different plural classes that have been presented for adults. The 37% and 39% relative frequencies of *-n* plurals in the present data are much less than the 53% to 68% based on CELEX counts (Clahsen 1999). For the so-called low-frequency plural classes, counts presented in Clahsen (1999) ranged from 2% to 8%; in the present study frequencies are nearer the upper boundary in most cases, and even reach 11% for the *-ø* pattern. These differences are attributed to the fact that adult speech analysed here is speech directed to young children, whereas frequency counts and estimates presented in Clahsen (1999) are based on adult-to-adult speech or on a small sample of speech to mainly older children (Wagner 1985). The present data show that when adults speak to young language-learning children the different plural classes are somewhat more evenly distributed, and classes which are often claimed to be very infrequent are less infrequent. Thus children are presented with more input of these plural markings than has been assumed so far.

Child growth rates of plural classes parallel adult input frequencies almost exactly, thus demonstrating a clear frequency effect. At 3;8 relative frequencies of use of plural classes correspond to adult frequencies, but at 2;10 this frequency distribution has not yet been reached, and there is a tendency for the differences between type frequencies per plural class to be less pronounced. These frequency distributions are determined by children's vocabularies. Small children tend to use basic words, and in German plurals of basic words are more evenly spread across the different plural classes than plurals of abstract and derived words (Duden 1995). The present results for adult plural use indicate that adults tend to adjust to this vocabulary to some extent, and in doing so adults present children with more opportunities for learning the less frequent plural markings.

What evidence is there for generalization of the different regularities of plural marking? Type frequencies of *-n, -e, -ø*, Umlaut+*-e* increase so rapidly that generalization seems more likely than rote learning. For plurals in *-s*, *-er* and Umlaut+*-er* growth rates are slow, but children use the suffixes *-s* and *-er* for erroneous marking, which is suggestive of generalization processes. The strongest evidence for generalization of the regularities involved is that errors occur which make use of all the different aspects of German plural marking, suffix affixation using *-n, -s, -e, -er,* and vowel change. Onset of errors is early, and there is no change over time in preferred error type. This is interpreted as support for the hypothesis that children learn the different patterns of regularities of the German plural system right from the beginning. Children might have started by using, for instance, the no marking error more frequently earlier on, with other errors increasing over age. This could have been indicative of a gradual involvement of the different regularities of plural marking. However, the data do not bear out such a strategy. Another point is that error rates for German plurals are much higher than those for English inflectional systems (Marcus *et al.* 1992, Plunkett & Marchman 1993). This persistently high error rate is probably due to the complexities of the German plural marking system. It would seem that acquiring a probabilistic system with multiple regularities, such as German plural marking, takes a different developmental route than that observed for learning a system divided into regular and irregular forms such as past tense or plural in English.

The types of errors are similar to the types of errors observed in other sets of spontaneous speech data (Gawlitzek-Maiwald 1994, Park 1978) and elicitation studies (Bartke 1998, Ewers 1999, MacWhinney 1978, Mugdan 1977, Schöler *et al.* 1998). However, none of the differing error preferences reported is confirmed by the present data. One reason for this could be that the quantitative basis of errrors is not large enough in any single study to detect the systematicity in error application. Another reason could be that the behaviour of older children in plural elicitation experiments does not reflect acquisitional behaviours. In particular, there is no evidence in the present data for the *-s* error being used most frequently and indiscriminately, i.e., irrespective of phonological context of endings, as Marcus *et al.* (1995) and Clahsen (1999) claim.

Rather, there is considerable evidence that error patterns reflect some of the regularities of the German plural marking system. The *-s* error is a fairly clear case of this. This error is most frequent for words which end in *-er*, whether in the singular or – for those cases when *-s* occurs as double marking – on the plural suffix *-er* (*kind-er-s* or *männ-er-s*). As final *-er* is pronounced [ɐ] in spoken German, it is highly likely that children apply the deterministic rule that words ending in an unstressed vowel take the *-s* plural allomorph, when they affix *-s* incorrectly. Thus, erroneous *-s* affixation is determined by the phonological context of word endings. The present data concur with the observation of Clahsen *et al.* (1992) that *-s* is an infrequent plural affix and yet is used as frequently as *-n* (a frequent plural affix) in erroneous marking. However, while Clahsen *et al.* (1992) take this as evidence for the default or regular status of *-s*, the present data demonstrate that the frequent use of erroneous *-s* affixation is largely restricted to a particular phonological environment in which *-s* is applied regularly in German plural marking. In this sense, the present data do not support a dual mechanism model of inflection (Clahsen 1999, Marcus *et al.* 1995, Pinker 1999). Erroneous affixation of *-s* occurs by rule of analogy.

The preference of partial marking for words taking an Umlaut+*-e* plural as opposed to those taking Umlaut+*-er*, is another case of the system's regularities underlying erroneous marking. For plurals with the *-er* suffix Umlaut must occur (Table 2), whereas for words taking the *-e* allomorph, Umlaut is only deterministic for feminine nouns, not for masculine and neuter nouns. While there is no tendency in the data that errors occur more frequently for masculine and neuter nouns, the greater indeterminacy of the system for Umlaut+*-e* may still be at the root of the errors.

For the *-n* and *-e* errors, regularities of phonological patterns may also play a role. While not significantly so, *-n* is affixed most frequently to a plural form ending in *-e*, and *-e* is used incorrectly instead of *-en*, although altogether quite infrequently. It could just be that children are confused occasionally as to when to use *-n* and *-e*. The reason would be that there are singular forms ending in *-e*, pronounced [ə], which take *-n* in the plural, and plural forms ending in the same sound [ə]. Further support for this interpretation could be that no marking occurs most frequently for *-n* and *-e* plurals.

If errors are classified in a way which is suggestive of different processing strategies – as was done for error types here – children's strategies for erroneous marking might be characterized as follows. There is a tendency to affix something to the ends of nouns, even if it results in double-marking (mostly with *-n*), or affix something (mostly *-s*) where a zero affix would be correct. Whether the latter strategy means that children tend to avoid zero suffixes (Pinker 1984) is unclear, as children in this study also used no marking quite frequently, and no marking is ambiguous with zero marking. No marking occurs quite frequently, and must therefore be considered as another strategy of coping with a highly complex plural marking system. Yet another strategy is to substitute one plural pattern for another, or part of a pattern for another (viewing partial marking as substitution). When children affix additional elements they prefer the pattern with the most rapid growth rate (*-n*) and the most deterministic pattern (*-s*).

A limitation of the present study is that most of the data analysis is based on only 6 subjects. Some effects in error analysis might have been significant in a larger sample. Also, differences between growth rates could have been tested at closer time intervals with a larger sample. However, error analysis results are backed up by the larger sample of 21 subjects with fewer speech samples, and for some of the frequency analyses this larger sample was used and did not differ from the smaller sample. One could also argue that, with respect to child language acquisition studies using extensive longitudinal speech data, a sample of 6 children is quite a large sample. Many conclusions concerning child language acquisition have been drawn, rightly or wrongly, on the basis of even smaller samples. For German plural acquisition the present analysis is based on the most comprehensive data set available to date.

Finally, there is no evidence in the present data that a dual structure of regular and irregular plurals is established early in German-speaking children (Clahsen 1999). There is, however, considerable evidence that patterns of different regularities are learnt and generalized early by these children. Thus, there is no need to invoke a special status of regularity for *-s* affixation (Clahsen 1999, Pinker 1999), given the weak empirical evidence for this view (Bartke 1998, Marcus *et al.* 1995) and the present empirical evidence against it. Reducing all plural formation patterns of German other than *-s* to the status of irregularity (Clahsen 1999, Marcus *et al.* 1995) does not do justice to a system with rich, but by no means arbitrary, regularities. Rather than attempting to fit a system with multiple regularities into the regular/irregular dualism of English morphology, such a system can be viewed as an exciting challenge to theories of morphological development, and it can help to advance our knowledge of how the mind builds up knowledge on the basis of probabilistic information in the input.

The present study uses frequency and error data in describing the course of acquisition of German plural marking, an inflectional system which has been a focus of recent debate. Frequency effects and error patterns in the present study provide some evidence that children learn the different plural markings by using distributional and frequency information contained in the input language. To clarify acquisitional processes of an inflectional system with multiple regularities in greater detail, neural network simulations using input frequencies actually available to young language learning children, as well as young children's vocabularies, could be a valuable next step.

REFERENCES

Augst, E. (1979). Neuere Forschungen zur Substantivflexion [Recent research on noun inflection]. *Zeitschrift für Germanistische Linguistik*, **7**, 220–32.

Bartke, S. (1998). *Experimentelle Studien zur Flexion und Wortbildung* [*Experimental studies on inflection and word formation*] (Tübingen: Max Niemeyer Verlag).

Clahsen, H. (1999). Lexical entries and rules of language: a multidisciplinary study of German inflection. *Brain and Behavioral Sciences: An Interdisciplinary Journal of Current Research*, **22**, 991–1060.

Clahsen, H., Rothweiler, M., Woest, A. & Marcus, G. (1992). Regular and irregular inflection in the acquisition of German noun plurals. *Cognition*, **45**, 225–55.

Duden (1995). *Grammatik der deutschen Gegenwartssprache*, Band 4 (*Grammar of contemporary German*, Vol. 4), 5th edn (Mannheim: Dudenverlag).

Elman, J., Bates, E., Johnson, M., Karmiloff-Smith, A., Parisi, D. & Plunkett, K. (1996). *Rethinking Innateness: A Connectionist Perspective on Development* (London: Bradford).

Ewers, H. (1999). Schemata im mentalen Lexikon: empirische Untersuchungen zum Erwerb der deutschen Pluralbildung [Schemata in the mental lexicon: empirical studies on the acquisition of German plural formation]. In J. Meibauer & M. Rothweiler (eds), *Das Lexikon im Spracherwerb* [*The lexicon in language acquisition*] (Berlin: Francke), 106–27.

Fenson, L., Dale, P., Reznick, J. S., Bates, E., Thal, D. & Pethick, S. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, **59** (5).

Gawlitzek-Maiwald, I. (1994). How do children cope with variation in the input? The case of German plurals and compounding. In R. Tracey (ed.), *How Tolerant is Universal Grammar? Essays on Language Learnability and Language Variation* (Tübingen: Niemeyer), 225–66.

Gravetter, F. J. & Wallnau, L. B. (1996). *Statistics for the Behavioral Sciences*, 4 edn (Minneapolis: West).

Hahn, U. (1999). The dual-route account of German: where it is not a schema theory, it is probably wrong. Commentary on Clahsen, H. (1999). Lexical entries and rules of language: a multidisciplinary study of German inflection. *Brain and Behavioral Sciences: An Interdisciplinary Journal of Current Research*, **22**, 1024–5.

Indefrey, P. (1999). Some problems with the lexical status of nondefault inflection. Commentary on Clahsen, H. (1999). Lexical entries and rules of language: a multidisciplinary study of German inflection. *Brain and Behavioral Sciences: An Interdisciplinary Journal of Current Research*, **22**, 1025.

Köpcke, K.-M. (1988). Schemas in German plural formation. *Lingua*, **74**, 303–35.

MacWhinney, B. (1978). The acquisition of morphophonology. *Monographs of the Society for Research in Child Development*, **43**.

—— (1987). The competition model. In B. MacWhinney (ed.), *Mechanisms of Language Learning* (Hillsdale, NJ: Lawrence Erlbaum), 249–308.

—— (1995). *The CHILDES Project: Tools for Analyzing Talk* (Hillsdale, NJ: Lawrence Erlbaum).

Marcus, G., Brinkmann, U., Clahsen, H., Wiese, R. & Pinker, S. (1995). German inflection: the exception that proves the rule. *Cognitive Psychology*, **29**, 189–256.

Marcus, G., Ullman, U., Pinker, S., Hollander, J., Rosen, T. & Xu, F. (1992). Overregularization in language acquisition. *Monographs of the Society for Research in Child Development*, **57**.

Miller, W. & Ervin, S. (1964). The acquisition of language. *Monographs of the Society for Research in Child Development*, **29**.

Mugdan, J. (1977). *Flexionsmorphologie und Psycholinguistik* [*Inflectional morphology and psycholinguistics*] (Tübingen: Narr).

Park, T.-Z. (1978). Plurals in child speech. *Journal of Child Language*, **5**, 237–50.

Pinker, S. (1984). *Language Learnability and Language Development* (Cambridge, MA: Harvard University Press).

—— (1991). Rules of language. *Science*, **253**, 530–5.

—— (1999). *Words and Rules: The Ingredients of Language* (London: Weidenfeld & Nicolson).

Plunkett, K. & Juola, J. (1999). A connectionist model of English past tense and plural morphology. *Cognitive Science*, **23**, 463–90.

Plunkett, K. & Marchman, V. (1993). From rote learning to system building: acquiring verb morphology in children and connectionist nets. *Cognition*, **48**, 21–69.

Rumelhart, D. & McClelland, J. (1986). On learning the past tenses of English verbs: implicit rules or parallel distributed processing? In J. McClelland, D. Rumelhart & the PDP Research Group (eds), *Parallel Distributed Processing: Explorations in the Microstructure of Cognition* (Cambridge, MA: MIT Press), 216–71.

Saffran, J. R., Aslin, R. N. & Newport, E. L. (1996). Statistical learning by 8-month-olds. *Science*, **274**, 1926–8.

Sarimski, K. (1987). *Ordinalskalen zur sensomotorischen Entwicklung* [*Ordinal scales of sensorimotor development*] (Weinheim: Beltz); German version of Uzgiris, I. & Hunt, J. (1975). *Assessment in Infancy: Ordinal Scales of Psychological Development* (Champaign: University of Illinois Press).

Schöler, H., Fromm, W. & Kany, W. (1998). *Spezifische Sprachentwicklungsstörung und Sprachlernen* [*Specific language impairment and language learning*] (Heidelberg: Edition Schindele).

Stern, C. & Stern, W. (1928). *Die Kindersprache* [*Children's language*] (Leipzig: Barth).

Szagun, G. (1999). *Rules for Transcribing and Analyzing German Child Language* (Institut für Kognitionsforschung, University of Oldenburg, Germany).
—— (2000*a*). The acquisition of grammatical and lexical structures in children with cochlear implants: a developmental psycholinguistic approach. *Audiology & Neuro-Otology*, **5**, 39–47.
—— (2000*b*). Learning the h(e)ard way: the acquisition of grammar in young German-speaking children with cochlear implants and with normal hearing. In Windsor, F., Kelly, L. & Newlett, N. (eds), *Themes in Clinical Phonetics and Linguistics* (Mahwah, NJ: Lawrence Erlbaum).
Wagner, K. R. (1985). How much do children say in a day? *Journal of Child Language*, **12**, 475–87.
Wurzel, W. U. (1984). *Flexionsmorphologie und Natürlichkeit* [*Inflectional morphology and naturalness*] (Berlin: Akademie Verlag).