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Incidental Word and Sound Errors in Young Speakers

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The question that is addressed by this study is whether the language production mechanism in children differs from the adult system. This problem is approached by comparing some 250 incidental, i.e., nonsystematic word and sound errors extracted from a corpus of tape-recorded spontaneous speech of two 2- to 3-year-old boys, with tape-recorded speech errors in the London–Lund corpus (Garnham, Shillcock, Brown, Mill, & Cutler, 1982. In A. Cutler, Ed. *Slips of the tongue and language production.* Berlin: Mouton). The adult data generally replicated findings reported in the literature, and, in turn, most of the error patterns in the children were similar to those in the adults, except for three differences. First, error frequency is considerably higher in children than in adults. Second, lexical substitutions involving phonologically similar words occur less often in the children than in the adults. Finally, in contrast to the adult corpus, the child corpus contains sound errors in function words. These differences are interpreted as indications of gradual developmental alterations in the language production mechanism, mainly reflecting the degree of practice and automatization.

In contrast to psycholinguists who deal with adults, child language researchers pay relatively little attention to comprehension and production processes. Most research efforts in developmental psycholinguistics are aimed at disclosing the mechanisms of language acquisition, which is not surprising in so far as the main characteristic of young language users is the rapid evolution of their linguistic knowledge. Although, obviously, the acquisition problem is central to developmental psycholinguistics, it is far from irrelevant to study the comprehension and production processes, or, to put it somewhat more formally, the functional architecture of the language mechanisms in children. Apart from being an interesting domain of inquiry in its own right, the analysis of language processing in children is crucial for the evaluation of one of the most widely held assumptions in language acquisition research, viz. that language processing mechanisms in children are essentially similar to those in adults. In effect, the analysis of language processing in children can be seen as an attempt to test this version of the *continuity* hypothesis (Pinker, 1984).

This paper specifically deals with the language production mechanism. Our understanding of language production in adults has profited quite substantially from analyses of speech errors, as is testified by a recent monograph on this topic (Levelt, 1989). Speech errors are seen as natural consequences of the structure of processing and may thus be employed as "windows into the mind" (Fromkin, 1971). Arguably, the study of language production in children should be approached similarly. Particularly, developmental changes might be traced by comparing child errors with adult errors. This is, at least in principle, not im-

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possible, since children begin to make speech errors at a very young age (Stemberger, 1989; Jaeger, 1990). There is one problem, however. Due to the acquisitional process, children's language output is far from stable. Consequently, it would be somewhat difficult to evaluate whether a particular piece of output constitutes a deviation due to incomplete linguistic knowledge, or a "genuine," incidental speech error. In this study, a corpus of child errors is analyzed that is derived from transcriptions of tape-recorded spontaneous speech. This method of corpus compilation enables a relatively safe method of distinguishing incidental, i.e., non-systematic, speech errors from systematic deviations. Moreover, the classifications and analyses of errors, particularly those involving sublexical elements, may be expected to be relatively unbiased and fine-grained, as compared to "traditional" paper-and-pencil studies (Ferber, 1991). In order to track down differences between children and adults, the child errors are compared to those from the London–Lund corpus of spontaneous speech (Garnham, Shillcock, Brown, Mill, & Cutler, 1982), which is also based on tape recordings.

Development of the Language Production Mechanism?

Two types of developmental change of the language production system are conceivable: *structural* change and *parametric* change. Structural change would involve a major alteration in the architecture of the system, such as the addition or, possibly, elimination of a processing subsystem. Such a hypothesis is less far-fetched than it may seem. For instance, it has been argued that in young children, who have a productive vocabulary of 50 words or less, phonological representations have not yet been analyzed into phonological segments (Waterson, 1971; Menn, 1983; Goodell & Studdert-Kennedy, 1990). If this is correct, it would imply that phonological encoding, i.e., a processing stage dedicated to the retrieval and ordering of segmental information, is not yet involved in the preparation of spoken utterances at this stage. Rather, there would be an immediate transition from the retrieval of meaning representations to the preparation of articulatory programs (Menn, 1983).

A structural change in the representation of word meaning with associated effects on lexical retrieval is described by Bowerman (1978). She analyzed a set of lexical substitution errors whose occurrence appeared to temporarily increase in her two daughters' speech between 2 and 4 years of age. Usually, these errors involved words that were semantically affiliated, as in the substitution of *put* for *make*, or *behind* for *after*. Bowerman argues that the temporary increase in such lexical substitutions is a reflection of the changes that occur in lexical memory as an overall semantic structure, that was hitherto not present, is acquired. In a similar vein, Wijnen (1990) argues that a temporary increase of dysfluent speech, which roughly coincides with the transition from so-called telegraphic speech to the initial use of morphosyntax, around age 2;6, reflects the development of a processor that is responsible for serial ordering in sentences and morphosyntactic computation, which is called the *positional planner* by Garrett (1975).

In contrast to structural change, *parametric* change refers to alterations of the "quantitative" aspects of the processing system, such as, the sizes of buffers needed to store intermediary processing results (Levelt, 1989), parameters related to the time course of information retrieval and buffering, the amount of parallelism in the system, or the extent to which processes are automatized. The results obtained by MacKay (1970a) seem to point to this kind of developmental change. MacKay (1970a), analyzing segmental transpositions from Meringer's corpus (Meringer, 1908, Meringer & Mayer, 1895), found that most of the distributional and statistical properties of adults' errors recurred in the child data,

albeit less strongly. For instance, whereas 90% of all transpositions in adults involve segments in corresponding syllable slots, agreement is only 70% in children. MacKay concluded that differences like these may reflect the children's lack of skill in language production as compared to mature speakers. Stemberger's (1989) results from a comparison of some 600 syntactic, lexical, and phonological errors with a large corpus of adult errors, seem to point in the same direction. Stemberger argues that most differences between the error patterns in adults and children reflect gradual, rather than principal changes in the language production system. A prominent factor in Stemberger's results is that perseveratory sound errors occur significantly more in children than in adults, which is taken to imply that, in terms of a parallel distributed processing network, the decay of activation of accessed items is slower in children than in adults.

As the above examples suggest, a *structural* change of the language production system may be dependent upon the acquisition of structural knowledge of language, which is reflected by the emergence of new (levels of) representation(s). This seems to entail a strong interdependence of the structure of linguistic knowledge and the structure of linguistic processing (cf. Jackendoff, 1987). *Parametric* change, on the other hand, may reflect an intrinsic, autonomous development of the processing system, which is, perhaps, related to overall age-related changes in information processing. However, it is also conceivable that structural change and parametric change are end points on a continuum, separated by a fuzzy transition. Consider, for instance, a parallel distributed processing mechanism. If a particular connection weight in such a network equals 0, the state of the node at one end of the connection does not affect that of the node at the other end. Functionally, a zero weight would imply that there is no knowledge of a relation between the units represented by the nodes at either end. A change of weight, resulting from learning, could thus be seen as the acquisition of knowledge: a *structural* change. From the point of view of the implementation of the processing system, however, a change like that would be merely parametric.

Comparison of Error Patterns in Adults and Children

This study starts from the assumption that if adults' and children's speech production mechanisms differ, different patterns of speech errors are to be found. However, since this is a data-driven study and since the inverse of the above implication (i.e., different error patterns imply different production mechanisms) is not necessarily true, an answer will be sought on both of the following questions: (1) in what respect and to what extent do children's speech errors differ from adults'; and (2) do such differences point to differences in the functional architecture of the speech production mechanism?

This study confines itself to lexical and sublexical errors. The primary (and somewhat prosaic) reason for excluding syntactic speech errors was that I was unable to find a reliable way to separate these in systematic and nonsystematic deviations. In the Method section below, more on the issue of recognizing incidental errors amidst typical systematic child language errors will be said. In spite of this limitation on the data, several aspects of the empirical problem spelled out above can be addressed. The present study will focus on three main points: (1) the frequency of errors; (2) the computational similarity constraint; and (3) the distinction between function words and content words.

Error Frequency

Speech errors are generally claimed to occur very rarely in adults (but see Ferber, 1991). Nevertheless, Warren (1986), on the basis of Freudian thinking, predicted that error frequency in children would be lower still. This appeared to be borne out by the

data. Aggregating data from various corpora of adult–child dialogue, Warren found only 19 errors in 196,400 words of child speech (0.096 per 1000 words), against 119 adult errors in 273,600 words (0.42 per 1000). This finding runs counter to a suggestion by Stemberger (1985). He argued that the child, being an apprentice in the art of speaking, is less in control of the skill than the adult, and will, therefore, produce more errors. Earlier, MacKay (1968) observed that the disruptive effect of *delayed auditory feedback* on speech production is stronger in children than in adults. This suggests that children indeed are "less in control" of their speech production mechanism, which, according to MacKay, is also reflected by their lower speech rate. The present study may shed some new light on this controversial issue.

Computational Similarity

Similarity of linguistic elements that are interchanged or substituted is a pervasive characteristic of speech errors. In spreading activation modelling, this is explained by the assumption that similar items are connected to the same nodes at an adjacent level in the network (Dell, 1986). Words that are substituted for one another, or blended, tend to belong to the same grammatical category (Nooteboom, 1969; Dell, 1986). Additionally, lexical errors often involve semantically related or phonologically similar words (Hotopf, 1980a; Fay & Cutler, 1977). Although the similarity is usually either semantic or phonological, there is evidence that even in substitutions and blends that appear to be primarily semantically motivated, the amount of phonological similarity of the interacting words exceeds chance levels (MacKay, 1973; Dell & Reich, 1981). This is suggestive of bottom-up feedback from the phonological level to the semantic ("lemma") level of processing.

At the sublexical level, the *similarity principle* is illustrated by several phenomena. Most errors at this level involve phonological segments (Shattuck-Hufnagel & Klatt, 1979; Stemberger & Treiman, 1986), which is often taken to imply that segments are the basic building blocks of phonological representations (Shattuck-Hufnagel, 1979; Dell, 1986). Target segments and intruding segments quite often are intrinsically similar by sharing all features but one. Moreover, they more often than not occupy corresponding syllable slots (Boomer & Laver, 1968; MacKay, 1970b). This observation has led to the hypothesis that phonological encoding encompasses the insertion of phonological "content" into syllabic address frames (Shattuck-Hufnagel, 1979; Meyer, 1990). Onsets seem to be more often affected by errors than other syllable constituents, which may be a reflection of the hierarchical structure of syllable templates (Fudge, 1969; MacKay, 1974; Treiman, 1983).

Content Words versus Function Words

Lexical errors such as substitutions and blends affect function words much less than would be expected on the basis of their frequency of use (Nooteboom, 1969; Hotopf, 1980a, 1980b; Stemberger, 1984; Dell, 1990). This finding, as well as results from experimental and clinical studies, has been taken to suggest that function words and content words constitute computationally distinct vocabularies (Garrett, 1982).

Phonological errors occur less often in function words than in content words. For instance, Stemberger (1984) found that of a total of 3379 phonological errors, 89.5% occurred in content words, 10.4% occurred in function words, and 0.09% occurred in affixes. Stemberger conjectures that function words (i.e., word forms) are easier to access than content words, primarily as a result of their very high frequency. Dell (1990) presents two alternative explanations. The first is what he calls the *special status* hypothesis: production of linguistic units that belong to closed classes[1] involve

[1] Note that this formulation implies that the hypoth-

direct retrieval, rather than indirect selection and ordering, of their constituents. The second is the *phonological* hypothesis: most function words and closed class morphemes belong the so-called phonological minor classes. They are normally unstressed, and for the most part unstressable, as well as amenable to reduction processes such as cliticization. It is known that sound errors show a tendency to avoid reduced and unstressed syllables. This could explain the virtual absence of function words as sound error targets. Dell's (1990) results seem to imply a primary role for frequency, although a "special retrieval" mechanism cannot be completely ruled out.

METHOD

Subjects, Recording, and Transcription

The child language corpus that is used in this study consists of transcriptions of two Dutch boys' home-taped spontaneous speech, N and T[2]. Approximately one hour of recording per week was collected during a 9 month period. T was observed from age 2;4 to 3;0, N from 3;0 to 3;10. T's mean length of utterance (MLU), computed according to Brown's (1973) criteria, was 1.9 at the beginning of the observation period, and 2.9 at the end. N's MLUs were 2.5 and 3.9, at beginning and end, respectively. These values suggest that in spite of the age difference, the children overlap in stage of grammatical development. In the phonological domain, N was somewhat backward in comparison to T. In particular, he exhibited a quite pervasive tendency to substitute alveolar consonants for back obstruents and clusters containing such consonants.

For each child, four samples of the recordings, each roughly covering one month (i.e., 4 to 5 h of recording) were orthographically, as well as phonetically, transcribed by two independently working, phonetically trained transcribers. Definitive transcriptions were obtained by comparing the initial versions and negotiating acceptable alternatives for parts that did not converge. If the transcribers could not reach an agreement on the correct transcription of an utterance, it was excluded from further analyses.

Recognizing Incidental Errors

Incidental errors are defined as deviations from the child's *own* linguistic standards, which usually differ from the adult system, as is often testified by systematic deviations from adult linguistic standards. Hence, in order to be able to evaluate whether an error is incidental, one needs to have a detailed picture of the child's linguistic behavior. This seems to rule out investigations based on observational notes, unless the observer has a sustained day-to-day contact with the child, to allow for an evaluation of the child's linguistic standards.

The present study is based on transcribed tape-recorded speech data. Thus, the potential systematicity of an error could be evaluated by checking whether identical or almost identical errors occurred elsewhere in the transcriptions, and if so, whether they were in some sense the outcome of a regular process. However, evaluating each error would have been an almost impossible task. Therefore, two less cumbersome methods to track potential incidental errors were used. First, the two persons who transcribed the tape-recordings from which the data in this research are drawn selected instances of error that they felt were nonsystematic. This was called "spotting." Since these transcribers, by virtue of their task, had had extended contact with the subjects, they were considered to have developed a good impression of the subjects' linguistic standards and could therefore evaluate the incidentality of deviations. Evidently, when the subject did not appear to have a

esis applies to *all* closed classes, not just function words.

[2] This boy was also the subject in an analysis of a speech error episode involving a tip-of-the-tongue phenomenon and some lexical blends, by Loekie Elbers (1985).

clear standard for a particular linguistic structure (e.g., the pronunciation of a certain word was unstable), "errors" and "correct" renderings could not be distinguished. The errors that were independently spotted by both transcribers were subjected to an additional, fairly conservative screening, in which errors that allowed for more than one interpretation, as well as any remaining cases that gave rise to the slightest doubt with regard to incidentality, were discarded.

The second method was to make an inventory of all instances of self-correction. Self-corrections had been identified during the course of transcribing, mainly on the basis of hesitatory and prosodic features. It should be stressed that only those self-corrections were included that had passed the transcribers' consensus procedure described above. Although using self-corrections may provide some guarantee that the errors are not only "in the ear of the beholder," but are considered errors by the subjects themselves as well, it is not a foolproof approach. For one, self-corrections in children may, apart from incidental errors, involve systematic deviations from adult standards (Clark, 1982). Additionally, speakers in general are known to repair not only speech errors, but also utterances that are pragmatically unacceptable (Levelt, 1983). Therefore, I inspected all self-corrections and removed those that appeared to involve systematic deviations or pragmatic failures. Three categories of errors were categorically discarded, viz. (1) errors involving deletions and/or misorderings of words (i.e., "syntactic" errors), which could not be reliably distinguished from a dominant type of systematic grammatical error; (2) all phonological errors affecting the voicing features of consonants, because the voiced–voiceless distinction apparently was not yet mastered by these subjects; and (3) phonological errors involving the substitution of alveolar plosives for back obstruents in subject N, in view of his habitual fronting. Of the two children's 266 word and sound errors, 82% are self-corrected.

Errors from the London–Lund corpus of spontaneous speech, published by Garnham et al. (1982), were used as comparison data. Garnham et al.'s method of corpus compilation is similar to that used for the child data:

> The texts were printed out from the computer tape. Each text was read by one of the authors, who, using very liberal criteria, marked every potential error. Then three or four of the authors met together to discuss each of these errors to decide if there was a plausible alternative explanation of the item, for example, as a false start. Those items which were judged to be genuine slips of the tongue were provisionally classified. Any remaining conflicts about the errors were resolved in further discussions when the final list was drawn up. (Garnham et al., 1982, p. 253)

The London–Lund corpus has two major drawbacks. First, it is fairly small; it contains some 155 errors (61% of which are self-corrected). This can be seen as an indication of the main problem in collecting errors from tape recordings: adult speakers produce so few errors that huge amounts of recorded speech are needed to compile a reasonably large corpus. Second, it is in English, rather than Dutch. Although English is closely related to Dutch, and traditional (non-tape-recorded) speech error studies in English and Dutch yield similar results (cf. Cohen, 1966; Nooteboom, 1969; Fromkin, 1971), there is a chance that differences between the child data and the adult data are an effect of language, rather than developmental stage. This problem cannot be solved in a principled way. Rather, for each adult–child difference, it will be necessary to argue that the language difference is not responsible.

Error Classification

Each error was classified on three dimensions, viz. *unit, process,* and *direction.* "Unit" refers to the linguistic structure that was affected by the error. It could either be a *word,* a *syllable,* a *segment* or *segment cluster,* or a *feature.* In general, I

chose the smallest unit possible, with one exception: if an error could be interpreted as both a sound substitution and a word substitution, I put it in the word category. There were only four of such cases in the final selection of child errors.

Error "process" refers to the description of the apparent change, which could be *omission, addition, substitution, blend, haplology, shift,* or *exchange.* "Direction" captures the type of interaction between utterance elements. I discriminated between *non-contextual* errors, i.e., errors which did not appear to involve the interaction of two or more elements within an utterance, and *contextual* errors. The latter were divided into *perseveratory* errors, in which an element interferes with the realization of an element in its right-hand context, and *anticipatory* errors, in which the interference is oriented to the left-hand context.

It is important to understand that in all cases, the localization of a putative source element *followed* determination of the—smallest possible—"unit." This has nontrivial consequences for the classification of sound errors in particular, because the type of putative source element is constrained by the "unit" classification of the affected element. For instance, a substitution of [n] for [m] would be classified as a feature error, particularly, as a substitution of the place feature "alveolar" for "bilabial." In this case, *any* alveolar consonant in the context would be a putative source. This classification procedure is more rigorous, as well as less impressionistic than what is usually done in "traditional" speech error research. It prevents a biasing effect on categorization which may result from the analyst's implicit intuitions or explicit preconceptions of "well-formed" speech errors.

As regards the London–Lund corpus, I generally maintained the "unit" classification that is suggested by the compilers. However, in certain cases, which will be discussed below, I disagreed with the authors' classification. These cases, as well as some of the children's, were marked as "doubtful," and were dismissed from the qualitative analyses. As regards "process" and "direction," I categorized the London–Lund errors according to my own criteria, which were, needless to say, identical to those used in classifying the child errors.

Results

Error Frequency

Table 1 summarizes the total numbers of errors as well as their frequency per 1000 words in each of the corpora. The figures in the table are approximations, since the exact number of words in the corpora could not be straightforwardly determined. The child corpora contain a considerable number of partly or wholly unintelligible or intranscribable utterances, which were coded as XXX, according to CHILDES conventions (MacWhinney & Snow, 1990). Two estimates of the numbers of words contained in these strings are given, one based on the substitution of one word for each XXX, yielding a maximal error frequency estimate, and one based on the substitution of the average number of words per utterance for each XXX, yielding a minimal error frequency estimate.

In the adult corpus, the major share of the material is formed by 34 samples of 5000 words each, obtained from speakers who were not aware of being recorded. However, the compilers of the London–Lund speech error corpus also included errors from the other speakers, (i.e., those who knew they were recorded), and I have been unable to find any information as to the number of words contributed by the latter group of subjects. Consequently, the frequency for the adult corpus is a maximum estimate.

Despite these uncertainties, the figures in Table 1 quite clearly suggest that children produce more errors than adults; in the most unfavorable case, the ratio is about 5 to 1. The error frequency does not show a clear decline as a function of age. However,

TABLE 1
ERROR FREQUENCIES IN EACH OF THE THREE CORPORA

Corpus	Number of words	Number of xxx		Number of errors	Errors/1000 words	
		Min	Max		Max	Min
London–Lund	>170,000	—	—	155	0.91	
T 2;4	2665	466	839	20	6.4	5.7
T 2;6	4121	382	993	36	8	7
T 2;8	4692	340	952	38	7.6	6.7
T 2;11	3703	167	518	27	7	6.4
T Total	15,181	1355	3302	121	7.3	6.5
N 3;1	3431	292	730	15	4	3.6
N 3;4	5525	250	750	27	4.7	4.3
N 3;6	6632	279	809	45	6.5	6.0
N 3;9	9955	544	2067	58	5.5	4.8
N Total	25,543	1365	4365	145	5.4	4.8

Note. The child corpora are divided according to age (years; months). Number of XXX represents the number of incomprehensible and/or untranscribable strings in the child corpora. Min/Max, is the estimated minimum/maximum number of words in these strings. The two rightmost columns give the corresponding maximal and minimal error frequency estimates.

the age range may be too limited to allow for the observation of such a tendency.

Selection from the Corpora

It is self-evident that speakers cannot err in speech forms they do not use. The children are at a stage of development at which productive morphology is very limited, which is reflected by the relatively low number of morphological errors.[3] By contrast, the adults err quite often in the application of morphology, in particular, with verb inflections and derivations. Examples are[4]:

(1) we kept [//] keep getting large sums (L-27-401)

(2) these are oral contraception [//] contraceptives (L-11-502)

It would seem illogical to compare two sets of data that are considerably different in composition. Therefore, I decided to discard all morphological errors, 23 in the adult corpus, and 5 in the child corpus.

Another problem presented itself in the form of errors that could not be categorized unequivocally with respect to the linguistic unit involved, or the purported process, or both. Notable instances of this kind of error are a number of slips in the adult corpus in which single phonological segments are produced out of place, as in:

(3) the rest of us [bə] uh [//] have been . . . (L-12-336)

(4) and [j] [//] when you finished . . . (L-13-530)

Similar cases in the child corpus are:

[3] It may be objected that, at this stage of development, morphological errors are probably always systematic. However, in view of the method by which errors were identified and screened, I can state with some confidence that the observed morphological errors were non-systematic.

[4] The canon in the transcription of error examples is as follows: The erroneous element is underlined. If a self-correction, indicated by [//], is absent, the intended element is added in parentheses, preceded by a right-pointing arrow (→). Other clarifications are also added in parentheses, preceded by an "equals" sign (=). If necessary, IPA transcriptions are included in brackets. Each example is identified by a capital letter, indicating the corpus (L [= adults], N, or T), a numeric code identifying the text, and the utterance number within the text segment. The Dutch examples are complemented by literal English translations, printed directly below the original text. If considered necessary, "free" translations, printed in *italics*, are added.

(5) [R] [//] paars
purple (T-111-91)

(6) koffie [k] voor Loekie
coffee for Loekie (T-31-7)

In these errors, the misplaced sounds can be interpreted either as the remains of anticipated or persevered words that were interrupted in the course of a spontaneous repair, or as segmental intrusions. Garnham et al. (1982) categorically considered these errors as segmental. I found them sufficiently ambiguous to exclude them from further analyses. There were 20 of such cases in the adult data and 25 in the child data. This leaves 112 adult errors and 236 child errors to be discussed in the remainder of this paper.

Lexical Errors

Several types of errors affecting whole words, which are enumerated in Table 2, were found in both the adult and the child corpora. Examples are given below.

Omissions:

(7) days _ (→on) which I can probably commute (L-110-1048)

Additions:

(8) made it all look what which it was . . . (L-23-301)

Substitutions:

(9) which is the American [//] the Australian expression (L-110-389)

TABLE 2
THE CATEGORIES OF LEXICAL ERRORS

	Adults	Children
Omissions	8 (10.3)	— (—)
Additions	4 (5.1)	— (—)
Substitutions	52 (66.7)	89 (93.7)
Blends/haplologies	8 (10.3)	3 (3.2)
Shifts/exchanges	3 (3.8)	3 (3.2)
Rest	3 (3.8)	— (—)
Total	78 (100)	95 (100)

Note. Percentages in parentheses.

(10) hij wil [//] kan gauw om
he wants can soon round (N-71-625)

(11) ik [//] Kim ook slapen hoor
I Kim also sleep y'hear (T-11-40)

Blends:

(12) that they [swIʃəl] (→ swish + swizzle) [//] swizzle things around (L-27-1300)

(13) de [sewRɑf] (→ zebra + giraffe) (T-121-68)

Haplologies:

(14) Mallet [nɛts] [//] never lets (L-12-636)

(15) [Rul] [//] groen stoel
green chair (T-184-25)

Shifts:

(16) we _ send it even up (→ we even send it up) (L-110-831)

Exchanges:

(17) it could well equally
(→ equally well) (L-28-83)

(18) konijn van schaduw
(→ schaduw van konijn)
rabbit of shadow
shadow of rabbit (T-123-155)

Note that word omissions are absent from the children's column in Table 2. These belonged to the—discarded—set in which systematic and nonsystematic deviations could not be separated. Lexical substitutions form the largest category and will be analyzed further in the next section. Errors other than substitutions are significantly more frequent in the adult corpus than in the child corpus ($X^2_{(1)} = 20.74$, $p < .001$). The "Rest" category, which appears only in the adult corpus, contains *tip*-of-the-tongue, rather than *slip*-of-the-tongue episodes.

Lexical Substitutions

Table 3 presents confusion matrices of the grammatical categories of the targets

TABLE 3
CONFUSION MATRICES OF GRAMMATICAL CATEGORIES OF TARGET WORDS AND INTRUDING WORDS IN NONCONTEXTUAL LEXICAL SUBSTITUTIONS

	Intrusion										
Target	N	V	Adj	Adv	Pro	Prep	Det	Rest	Total	%	% Corpus
(a) *Adults*											
N	12	—	—	—	—	—	—	—	12	26.1	
V	—	2	—	—	—	—	—	—	2	4.3	
Adj	1	—	6	—	—	—	—	—	7	15.2	
Adv	—	—	—	1	—	—	—	—	1	2.2	
Pro	—	—	—	—	13	—	—	—	13	28.3	
Prep	—	—	—	—	—	10	—	—	10	21.7	
Det	—	—	—	—	—	—	1	—	1	2.2	
Total	13	2	6	1	13	10	1	—	46	100	
(b) *Children*											
N	10	—	—	—	2	—	—	—	12	14	21.5
V	—	36	—	—	—	—	—	—	36	41.9	23.2
Adj	—	—	2	—	—	—	—	—	2	2.3	4.3
Adv	—	—	—	5	2	—	1	—	8	9.3	19
Pro	—	—	—	1	12	—	—	—	13	15.1	15.3
Prep	—	—	—	—	—	12	—	—	12	14	5.4
Det	—	—	—	—	—	—	3	—	3	3.5	4.6
Total	10	36	2	6	14	12	4	—	86	100	100

and intrusions in noncontextual lexical substitutions, which are slightly more frequent in children than in adults (97% vs. 88%, $\chi^2(1) = 3.66$, $.10 > p > .05$). The grammatical categories of target words and intruding words usually match, although the percentage of matches is somewhat—though nonsignificantly—lower in the children than in the adults (93% vs. 97.8%). Substitutions of function words (i.e., pronouns, prepositions, determiners, and adverbs[5]) occur slightly, but not significantly more often in the adults than in the children (54% vs. 41.9%; $\chi^2(1) = 1.88$).

The sets of substituted words are differently composed in adults and children. In particular, verbs are more prominent in the child corpus than in the adult corpus. Verb targets in the child corpus are even more numerous than expected on the basis of relative frequencies in the full speech corpus (N: 46% of the targets, 24.3% in the full corpus, T: 32% vs. 21.3%). The difference between the set of substitution targets and the full speech corpus with respect to the relative frequency of verbs is significant ($\chi^2(1) = 16.7$, $p < .001$). Most of the children's verb targets (81.5% in N, 77.8% in T) share two characteristics, viz. finiteness, and left-peripheral (i.e., first or second) position in the sentence. Examples are:

(19) moet [//] gaat ie heel hard zingen
must goes he very loud sing
he's going to sing very loud
(N-153-53)

(20) ik mag [//] ik moet ə in ə papier doen
I may I must in paper do
I have to put it in paper (T-241-65)

Both in the adults and in the children, several lexical substitutions involved conceptually related words. In this analysis, the following types of conceptual relation were distinguished:

[5] Adverbs that can also occur as adjectives were excluded from this category.

Coordination:

(21) the [kæ] (= catholics) [//] the [/]
the protestants (L-28-289)

(22) ik zoek ə kiepauto [//]
graafmachine
I look for dump truck
dragline (N-172-433)

(23) en dat is blauw [//] geel
and that is blue yellow
(T-103-25)

Synonymy:

(24) is geen [//] is niet nacht
is NEG is not night (N-161-89)

Antonymy:

(25) daar komt [//] gaat die politie
there comes goes that police
(N-71-163)

(26) niet [//] wel waar
not AFF true (T-185-8)

Apart from these formal semantic relations, some instances were observed in which the interacting words were *associatively* related:

(27) list of advertisements
(→ applicants) (L-32-662)

(28) niet weggooien [//] niet kapotmaken
don't throw away don't break
(N-23-187)

(29) zo hoge hijskraan [//] zo hoge
schoorsteen
such high crane such high
chimney (N-171-138)

Since function words were substituted as well, some criteria had to be devised for the determination of conceptual similarity in these cases. Locative prepositions, such as *in, on, before,* and *behind* were considered to be *coordinates,* i.e., members of the same semantic field. The same applies to personal and demonstrative pronouns. All other combinations of function words were deemed conceptually unrelated.

Table 4 provides a breakdown of the set of lexical substitutions in both corpora according to the presence or absence of a conceptual relation. Apparently, the words interacting in lexical substitutions are more often semantically or associatively related in adults than in children ($\chi^2(1) = 4.41, p < .05$; "other" errors are disregarded). In both corpora, however, most conceptually related target–intrusion pairs are coordinates (or cohyponyms) (adults: 54.3%, children: 39.5%). The category of "other" relations is more prominent in adults than in children. In this category the intruding words usually are collocationally related to the preceding context, as in:

TABLE 4
CONCEPTUAL RELATIONS IN NONCONTEXTUAL LEXICAL SUBSTITUTIONS

		Children	
	Adults	all words	V excluded
No relation	11 (23.9)	39 (45.3)	15 (30)
Semantic	26 (56.5)	40 (46.5)	30 (60)
Associative	4 (8.7)	5 (5.8)	4 (8)
Other	5 (10.9)	2 (2.3)	1 (2)
Total	46 (100)	86 (100)	50 (100)

Note. Percentages in parentheses.

(30) he was offered an engineering
degree [//] engineering job
(L-113-164)

(31) nog ə keer [//] nog ə pap
another time another porridge
(T-23-36)

Substitutor–substitutee pairs without a conceptual relation seem to form a mixed bag. In the adult corpus, most of these appear to be phonologically similar, as in:

(32) A notch (→niche) was made for
Raleigh (L-36-101)

These will be discussed below. In the child corpora, 19 of the 39 conceptually unrelated target–intrusion pairs (48.7%) involve the left-peripheral, finite verbs mentioned above. Many of these verbs are (modal) auxiliaries, which do not have much semantic content. This may have introduced a bias in the child data. Therefore, the pro-

portions of conceptually related substitutions in the child corpus were recalculated, excluding all verbs. This yields the figures in the third column of Table 4, which do not differ significantly from those of the adults ($\chi^2(2) = 1.88$).

To evaluate whether word form affects lexical substitution, each target–intrusion pair was scored for similarity on four aspects of phonological structure: (1) initial segment; (2) final segment; (3) stressed vowel; (4) number of syllables. Example (33) is a substitution in which target and intrusion share the initial segment. Word final segments of target and intrusion are similar in example (34). Stressed vowels are identical in (35). In example (36) the numbers of syllables of the involved words match.

(33) daar . . . daar [//] dit ben ik
there . . . there this is me
(N-222-166)

(34) jij boterham maken [//] halen
you sandwich make fetch
(N-33-63)

(35) Loekie [//] Roef kan wel praten
Loekie Roef can AFF talk
(T-263-14)

(36) ik wil even spelen [//] praten
I want just play talk
I want to talk for a while
(N-161-367)

For each substitutor–substitutee pair a similarity score was calculated by adding one point for each correspondence. Thus, the minimal score was 0, i.e., no correspondences, and the maximum score was 4; i.e., the interacting words match on each of the four phonological aspects. Of course there is a gradual transition from total dissimilarity to total similarity, but for the purpose of this analysis, the continuum was dichotomized by setting a more or less arbitrary line between the scores two (half the number of phonological attributes match) and three. Word pairs with a score of two or lower were deemed "dissimilar," those scoring three or higher "similar." Table 5 gives the numbers of similar and dissimilar word pairs, cross-classified according to the absence or presence of a conceptual (semantic or associative) relation. The totals in this table do not fully correspond to those in the previous one, which is due to the fact that in some cases the phonological characteristics of either of the interacting words could not be decided on, for instance, as a result of self-interruption.

TABLE 5
PHONOLOGICAL SIMILARITY IN NONCONTEXTUAL LEXICAL SUBSTITUTIONS WITH AND WITHOUT A CONCEPTUAL (I.E., SEMANTIC OR ASSOCIATIVE) RELATION

	Dissimilar	Similar	Total
(a) *Adults*			
Conceptually related	22 (81.5)	5 (18.5)	27 (100)
Unrelated	4 (36.4)	7 (63.6)	11 (100)
(b) *Children*			
Conceptually related	39 (88.6)	5 (11.4)	44 (100)
Unrelated	34 (87.2)	5 (12.8)	39 (100)

Note. Percentages in parentheses.

In the child corpus, the proportion of phonologically similar target–intrusion pairs is significantly lower than in the adults' corpus (N: 14.3%; T: 7.4%; $\chi^2(1) = 6.68$, $p < .01$). To evaluate the statistical relation between conceptual relatedness and phonological similarity of substituted and substituting words, a priori probabilities were computed on the basis of repeated random pairing (five times in all) of substituting and substituted words. The expected proportion of substitutions involving a phonologically similar target-intrusion pair (i.e., a match on at least three out of four phonological aspects) was thus found to be 0.065 for both children and adults. In the child corpus, the observed number of phonologically similar substitutions exceeds chance estimates in both conceptually related and unrelated pairs, but not significantly so (Kolmogorov–Smirnov $D = 0.06$ for both sets). In the adult corpus, on the other hand, substitutions in which target

and intrusion are conceptually unrelated involve approximately 10 times more phonologically similar words than is expected (Kolmogorov–Smirnov $D = 0.58, p < .01$). In substitutions of conceptually related words, phonologically similar target–intrusion pairs are still more frequent than expected (by a factor 2.8), although not significantly so (Kolmogorov–Smirnov $D = 0.12$).

Sound Errors

Sub-lexical errors either involved syllables, segments, or features.

Syllables:

(37) guarantee us a [_gri:] (→ degree) (L-33-710)

(38) Ker_ (→ Kermit) moet hand in ə mond
Kermit must hand in mouth
Kermit has to put his hand in his mouth (T-186-115)

(39) kom Sin _klaas [//] Sinterklaas
comes Santa Claus (N-101-309)

(40) is [nəʃ] [//] nog niet
is yet not
is not yet (N-182-44)

Segments:

(41) to [brai] (→ buy) the Irish press (L-114-320)

(42) ik ga voor jou tape-recorder fewaren (→ bewaren) hè
I go for you tape-recorder keep eh
I'm going to keep the tape recorder for you (T-261-48)

(43) zit onder austo's (→ auto's)
sit underneath cars (N-161-112)

Features:

(44) thunderous [əprɔz] (→ applause) (L-211-13)

(45) [kɛiŋ] deze [//] kijk deze
look at this one (T-251-19)

(46) op kom [//] op kop leggen
on head lay
lay on its head (N-23-137)

Table 6 presents the numbers of sound errors—both contextual and noncontextual—involving the various units of description. There are some differences between adults and children with respect to the proportions of contextual and noncontextual errors and the proportions of affected units, but these do not reach significance (contextual vs. noncontextual: $\chi^2(1) = 2.67$; units: $\chi^2(2) = 3.12$).

Table 7 shows the distribution of sound errors over words of different grammatical classes. In the adult corpus, virtually all errors occur in content words (N, V, Adj). Since it is save to assume that at least 50% of all words produced by adults are func-

TABLE 6
CONTEXTUAL AND NONCONTEXTUAL SOUND ERRORS AFFECTING VARIOUS UNITS OF DESCRIPTION

	Feature	Segment	Syllable	Total
(a) *Adults*				
Noncontextual	3 (18.8)	9 (56.3)	2 (100)	14 (41.2)
Contextual	13 (81.2)	7 (43.7)	—	20 (58.8)
Total	16 (100)	16 (100)	2 (100)	34 (100)
(b) *Children*				
Noncontextual	17 (32.7)	41 (65.1)	22 (84.6)	80 (56.7)
Contextual	35 (67.3)	22 (34.9)	4 (15.4)	61 (43.3)
Total	52 (100)	63 (100)	26 (100)	141 (100)

Note. Percentages in parentheses.

TABLE 7
THE CATEGORIES OF WORDS HIT BY SOUND ERRORS

	N	V	Adj	Adv	Pro	Prep	Det	Rest	Total
Adults	14	8	10	—	—	—	—	2	34
	(41.2)	(23.5)	(29.4)	—	—	—	—	(5.9)	(100)
Children	50	40	9	16	14	2	1	3	135
	(37)	(29.6)	(6.7)	(11.9)	(10.4)	(1.5)	(0.7)	(2.2)	(100)

Note. Percentages in parentheses.

tion words, the proportion of function words in the error set clearly deviates from a chance expectation. In the children, over 24% (N: 27.9%, T: 20.9%) of all sound errors occur in words that belong to one of the minor classes: Adv, Prep, Det, and Pro. Still, more sound errors occur in content words than is expected on the basis of the relative frequencies of word classes in the full corpus (as specified in Table 3; $\chi^2(1) = 32$, $p < .001$).

In the light of Stemberger's (1984) and Dell's (1990) findings regarding the effect of frequency on words' vulnerability to sound errors, the overall absolute frequencies of occurrence of all words in the two child corpora were computed. The resulting distribution allows for an estimation of the relative frequency of the words involving sound errors. It appears that 12 out of the 14 function words hit by sound errors in T's corpus have a percentile rank of at least 90, 10 of these rank above the 95th percentile. In N's corpus, all 19 function words affected by sound errors rank above the 92nd percentile; 15 exceed the 98th percentile rank. Apparently, most function words hit by sound errors in the child corpora are among the most frequently used words, as they are in adult speech.

One objection that can be raised against this analysis is that while the overall frequency of a particular word in the corpus as a whole may be considerable, the error may have occurred at a moment at which this word was still very infrequently used, since the lexical inventories of these subjects are rapidly evolving. To compensate for this problem, the frequencies of occurrence of the function words hit by sound errors were also determined within four portions of both corpora, each of which covers a restricted age range. For instance, if an error occurred in word X at age 2;5, the frequency of that word in the subcorpus covering that age was determined. It turned out, however, that this approach produced the same results.

As the vulnerability of words to sound errors may be related to their phonological characteristics, the set of target words was further inspected in this regard. It appeared that very few of the target function words (4 in T, 1 in N) are clitics. Of the remaining set, all can receive stress, and some (2 in T, 3 in N) are polysyllabic. However, even function words with such "nontypical" phonological characteristics do not occur in the adult sound error corpus.

The Loci of Segment and Feature Errors

The remainder of this section will be concerned with subsyllabic (segment and feature) errors, which constitute the lion's share of sound errors in both adults and children. Table 8 gives the numbers of segment and feature errors affecting either of the three syllable constituents. In both the adults and the children, syllable onsets are slightly more often affected than either nuclei or codas. Although the effect appears to be somewhat stronger in the adults than in the children, the difference in distributions does not reach significance ($\chi^2(2) = 3.82$). To evaluate whether the distributions of error loci differ from chance expectations, based on the overall properties of the corpora, all actual occurrences of onset,

TABLE 8
THE DISTRIBUTION OF SEGMENT AND FEATURE ERRORS OVER SYLLABLE CONSTITUENTS

	Onset	Nucleus	Coda	Total
Adults				
Observed	18 (58.1)	9 (29)	4 (12.9)	31 (100)
Expected	11.5	12.6	6.8	
Children				
Observed	45 (41.7)	32 (29.6)	31 (28.7)	108 (100)
Expected	41.3	45.7	21.1	

Note. Percentages in parentheses.

nucleus, and coda in the sets of words struck by a sound error were counted. The entries under the heading "expected" in Table 8 are derived from these estimates. Chi-squared tests indicate that the difference between observed and expected distributions is significant in the children ($\chi^2(2) = 9.1, p < .02$), and nearly significant in the adults ($\chi^2(2) = 5.92, .06 > p > .05$). The effect in the children appears to reflect an elevated number of coda errors and a reduced number of nucleus errors. The adults, on the other hand, produce a disproportionate number of onset errors.

All segment and feature errors were classified according to whether they occurred in stressed or unstressed syllables. To avoid confounding of word class and stress, the errors in function words were excluded.

Table 9 shows the observed distribution of sound errors over stressed and unstressed syllables, as well as a chance estimate based on the numbers of stressed and unstressed syllables in the sets of words in which the errors occurred. The observed and expected distributions differ significantly in both children and adults (adults: $\chi^2(1) = 6.71, p < .01$; children: $\chi^2(1) = 11.36, p < .001$), which indicates that stressed syllables are more vulnerable than unstressed ones. The effect seems to be somewhat stronger in the adults than in the children, but this difference does not reach significance.

TABLE 9
SOUND ERRORS IN STRESSED AND UNSTRESSED SYLLABLES

	Unstressed	Stressed	Total
Adults			
Errors	5 (16.1)	26 (83.9)	31 (100)
Chance	24 (43.6)	31 (56.4)	55 (100)
Children			
Errors	18 (23.4)	59 (76.6)	77 (100)
Chance	67 (46.5)	77 (53.5)	144 (100)

Note. Percentages in parentheses.

Contextual Errors

Table 10 gives the numbers of anticipatory segment and feature errors, perseveratory errors, and exchanges. Classification depended on the location of the putative source element closest to the target. If no decision could be made in this respect, the error was classified as "undeterminable." Anticipations were subdivided into completed and interrupted errors. In the latter, a self-correction occurs between the locus of the error and the putative location of the source segment. Such errors could in fact represent exchanges or shifts that are interrupted before the second element of the error is produced.

Thirteen errors (68.4% of 19 classifiable) in the adult corpus and 32 errors (58.3%) in the child corpus involved between-word interactions. In the adult corpus, anticipations and perseverations appear to occur with equal frequencies. This result is not consonant with the generally reported predominance of anticipatory errors. Presumably, this is related to the method of identification of the putative source element used in this study. In the child corpus, anticipation is somewhat more frequent than perseveration. However, the adult–child difference does not reach significance. The composition of the set of anticipations, on the other hand, does differ between adults and children. All but one of the adult's anticipations (88.9%) are interrupted, whereas in the children only 39% are ($p = 0.12$, Fisher's exact probability test). This might reflect a developmental difference in the ability to monitor and self-correct speech.

TABLE 10
DIRECTIONS OF INTERACTION IN CONTEXTUAL SEGMENT AND FEATURE ERRORS

	Anticipation					
	Complete	Interrupted	Perseveration	Exchange	Undet	Total
Adults	1 (5)	8 (40)	9 (45)	1 (5)	1 (5)	20 (100)
Children	17 (29.8)	11 (19.3)	23 (40.4)	3 (5.3)	3 (5.3)	57 (100)

Note. Percentages in parentheses.

Table 11 addresses an aspect of the structural similarity of source and target elements in contextual segment and feature errors. In 65% of the cases in the adult corpus, and 74% of the cases in the children's corpus, the syllabic positions of target and source elements match. This difference is not significant ($\chi^2(1) = 0.59$).

Feature Errors versus Segment Errors Reconsidered

The raw data indicate that both in the adults and in the children, feature errors are roughly as frequent as segmental errors (cf. Table 6). Recall, however, that the present set of errors was categorized in terms of the smallest possible linguistic element. A consequence of this classification criterion is that the set of feature errors may contain both unambiguous (of the *clear blue sky* → *glear plue sky* type) and ambiguous errors (like *barn door* → *darn bore*). The latter may be construed as interactions of segments differing in just one feature. Examples of ambiguous feature errors from the present corpora are the following (putative sources are in boldface):

(47) a [b̲ʌ] [//] double bed (L-114-369)
(48) taart mee getomen (→ gekomen)
pie along came
pie came along (T-92-79)
(49) Sinterklaas op de [k̲Il] [//]
Sinterklaas op de televisie
Santa Claus on the television
(T-172-1)
(50) daar de man niet [αfpαp̲ə] [//]
afpakken
there the man not
snatch away
(N-154-296)

Examples of unambiguous feature errors are:

(51) what I've done is simply choo[s̲] (L-14-385)
(52) net [α] [//] met appel
with apple (T-32-11)
(53) televitie uh [//] televisie kijken
television watch
(T-23-298)

Eight out of the 13 contextual feature errors in the adult corpus, and 21 out of the 35 in the child corpus are ambiguous. When we distract these numbers from the total numbers of contextual feature errors, it turns out that 25% of the subsyllabic contextual errors in the adult corpus unambiguously affect single features. In the child corpus, the percentage is 24.6%. If the ambiguous feature errors are considered as interactions between highly similar segments, they make up 53.3% of the segment errors

TABLE 11
SYLLABIC LOCATIONS OF TARGETS AND SOURCE ELEMENTS IN CONTEXTUAL SEGMENT AND FEATURE ERRORS

	Target		
Source	Onset	Nucleus	Coda
Adults			
Onset	10	0	2
Nucleus	0	3	0
Coda	5	0	0
Children			
Onset	24	0	9
Nucleus	0	7	0
Coda	5	0	9

in the adults corpus and 48.9% in the child corpus. These percentages do not differ significantly.

Discussion

The aim of this study was to decide whether the functional architecture of the language production mechanism in children differs from that in mature speakers. To reach this goal, speech errors extracted from transcriptions of longitudinal speech corpora of two 2–3-year-old children were compared with adults' slips of the tongue from the tape-recorded London–Lund corpus of spontaneous speech. The analyses were concentrated on three issues: the frequency of errors, the computational similarity principle, and the different participation rates of content words and function words in lexical and phonological errors. Some differences between adults and children, as well as some correspondences were found. However, as was pointed out before, a difference between adults and children is in itself not sufficient to conclude that the language production mechanism is subject to developmental change. Such a conclusion can only be reached when there is sufficient reason to reject other, simpler explanations. What will complicate this discussion to some extent is that in a few cases the adult data differ from what has been reported before. Mostly, these discrepancies will be argued to result from differences in methodology, which underscores its exceedingly critical role in speech error research. Additionally, in some cases we will have to decide whether a difference may be an "artifact" of the difference in language between the adults and the children.

Error Frequency

In contrast to Warren's (1986) finding, the present results suggest that incidental speech errors are considerably more frequent in children than in adults. What could be the reason for this contrast? Stemberger (1989) points out that Warren may have overestimated the frequency of errors in adults by including hesitations after which the speaker decided to say something other than originally intended. "Additionally, the adults in the study had more things (and people) claiming their attention than the children did, which probably contributes to higher error rates" (Stemberger 1989, p. 165, Note 1). The latter remark refers to a difference in setting in which the child and adult corpora studied by Warren were collected. At least in this respect, the present comparison is more valid, since both the adult and child speakers were recorded during conversations with at most one interlocutor. Moreover, it is unlikely that the difference found here could be explained as an artifact of inconsistent error collection methods. Although the children's and adults' errors were recorded by different persons, the methods of corpus compilation were similar to a satisfying degree. Also, it is hard to maintain that transcription in the London–Lund corpus was less sensitive than in the child corpora. The source texts, published by Svartvik and Quirk (1980), testify to the fact that even the smallest deviations from the expected forms (such as voicing errors) were noted. Lastly, it seems perfectly reasonable to exclude the language difference as a source of variation. There is no reason whatsoever to believe that any language is inherently more "error-prone" than any other language.

The present data agree with the results of a recent study of experimentally induced slips of the tongue in which 5-year-old children were found to produce 2.5 times as many errors as adults (Smith, 1990). Consequently, it seems fair to conclude that children produce more speech errors than adults. As regards an interpretation of this finding, Stemberger's (1985) suggestion that children are "less in control" of speech production processes than adults has an attractive ring. I would prefer, however, to substitute the notion "being less in control" by "a lesser degree of automatization," which is more in agreement with

MacKay's (1968) formulation. It is quite evident that speech production in adults is a highly overlearned, and therefore highly automatic, skill. Once set in motion, highly automatized skills run down like reflexes, effortlessly, beyond conscious control, and relatively unaffected by simultaneous activities or processes (not completely, as the quote from Stemberger above suggests). Hence, they are much less error-prone than controlled, attentive processes. (The price that is paid is, of course, a lack of flexibility.) Skills, in general, become automatized as a result of practice (Neisser, 1983; MacKay, 1987). Language production skills in young children can be presumed to be not yet automatized and still highly effortful (Elbers & Wijnen, 1992). The difference in error rate between children and adults found in this study supports this conjecture.

Computational Similarity

The results with respect to the grammatical, semantic, and phonological similarity in lexical substitutions bear on this issue. In the adult corpus, a "grammatical class constraint" was observed, which was reported before by, among others, Nooteboom (1969) and Fay and Cutler (1977). Also, in a considerable number of substitutions (over 56%), target words, and intruding words are semantically related. This replicates earlier findings, although the reported proportions of semantically motivated lexical substitutions appear to vary quite substantially over different studies, from 35% (Hotopf, 1980a), to 45% (Dell & Reich, 1981) to 83% (Stemberger, 1989), which may be related to differences in definitions of semantic relatedness. Finally, the present results showed that, for the adults, a number of substitutions involve phonologically similar words and that there is a "trade-off" between phonological similarity and semantic similarity. It is not the case, however, that conceptual and phonological similarity are mutually exclusive; the number of phonologically similar target–intrusion pairs in conceptual substitutions exceeds a chance estimate, although not significantly.

The grammatical class constraint is not only observed by the adults, but by the children as well, which seems to imply that syntactic planning in these children and adults is essentially similar. This process has been portrayed as the insertion of lexical items into syntactically defined frames (Garrett, 1975; Dell, 1986). Hence, the present data support the idea, put forth on the basis of distributional analysis of child utterances, that even at the early age of 2 to 3 years, the lexicon is differentiated in terms of syntactic classes (Valian, 1986; Ihns & Leonard, 1988).

At first sight, the number of conceptually similar target–intrusion pairs in the children's lexical substitutions appeared to be considerably lower than in adults. However, this appeared to be an artifact of the large proportion of substitutions of left-peripheral, finite verbs in the child corpus, many of which are auxiliaries and modal verbs, which do not have much conceptual content to begin with. It is not quite clear why the left-peripheral finite verbs are so prominent in the children's substitutions. It might be a reflection of differences between Dutch and English, for example, with regard to the relative frequency of use of the various syntactic categories. One argument against this interpretation can be derived from the fact that the percentage of verb error targets in Dutch adults, as reported by Nooteboom (1969), is lower than in the child subjects of this study, viz. 14.3%. This would suggest that the present result primarily reflects an adult–child difference, rather than an English–Dutch difference. It may be related to the acquisition of the feature finiteness, which has been suggested to be typical for 2- to 3-year-old Dutch children (De Haan, 1987; Jordens, 1990). Perhaps, in analogy to the increase of semantically motivated substitutions described by Bowerman (1978), the discovery of the finiteness and its syntagmatic, i.e., *positional,* correlates leads to a "reorganiza-

tion" of the mental lexicon, resulting in a (temporary) increase of errors involving words that share the feature. This hypothesis should be further explored in a detailed longitudinal analysis of error frequencies and patterns, along the lines of Wijnen (1990).

Phonologically similar target–intrusion pairs in lexical substitutions were found to be less frequent in the children than in the adults. Even in the children's conceptually unrelated substitutions, the number of phonologically similar word pairs did not significantly exceed a chance estimate. The implication seems to be that the retrieval of word forms in children is less affected by structural similarities than in adults. It is unlikely that this result is related to the language difference, given the fact that the a priori chances of phonological similarity in a randomly selected word pair were equal for both corpora.

Would this finding point to a difference in the language production mechanisms of adults and children? In a spreading activation model of lexical processing, such as the one proposed by Dell (1986, 1988), the intrusion of a non-intended, phonologically similar word can be explained by an appeal to backward spreading of activation from the phonological level to the word (lemma) level. Now if the low frequency of phonologically similar substitutor–substitutee pairs in children is valid, it could imply that backward spreading of activation from phoneme nodes to word nodes is restricted. Interestingly, starting from a different phenomenon, viz. the lack of a repeated phoneme effect in children's contextual segment errors, Stemberger (1989) arrives at the same interpretation. It is somewhat confusing, however, that despite this convergence, Stemberger reports that phonological word substitutions were more frequent in children than in adults, which contrasts with the results of this study. It should be stressed, however, that, first, Stemberger's method of classifying lexical substitutions probably differed from the one used in this study and, second, that Stemberger did not test the number of observed phonological substitutions against a chance expectation, as was done in this study. At any rate, it is clear that this issue is in need of some more research, preferably with the aid of simulation models.

With respect to the sound errors, two sets of results are pertinent to the issue of computational similarity, neither of which seem to indicate a principal difference between adults and children. First, it was observed that in both children and adults a majority of the contextual feature and segment errors involved the interaction of units from parallel syllable positions, which corresponds to earlier findings (e.g., MacKay, 1970b). On the basis of this finding, it seems fair to conclude that the basic mechanism in phonological encoding is essentially the same in adults and children. Presumably, this mechanism concurs with the slot-filler algorithms that have been proposed in the literature (Shattuck-Hufnagel, 1979; Dell, 1986).

Second, the reanalysis of the single feature errors yielded a pattern of results that seems to point to a parallel between children and adults with respect to inherent segment similarity. Ambiguous contextual feature errors, reanalyzed as interactions of minimally different segments, appeared to represent approximately 50% of all contextual segment errors, both in the adult and the child corpus. Incidentally, these data seem to underscore the primary role of phonological segments in the process of phonological encoding in both adults and children. The percentage of unambiguous feature errors is around 25%, which is similar to figures reported elsewhere (e.g., Stemberger & Treiman, 1986).

Function Words versus Content Words

With regard to the participation of function words in lexical substitutions, the present data for the adults seem to differ from those reported previously. Nooteboom (1969) found three substitutions of

prepositions in a set of 21 (14%), Hotopf (1980a, 1980b) reports percentages of function word substitutions between 0 and 5, and Stemberger (1984) found 11.5% function word targets in a set of 846 lexical substitutions. These figures are clearly lower than the 54% that is observed in the present study. This may be due to a difference in error collection methods. Since function words are often unstressed and reduced, it is quite likely that any errors in them will go unnoticed by a speech error collector who relies on the naked ear. When speech errors are gathered from detailed (phonetic) transcriptions, on the other hand, errors in function words are no less conspicuous than those in content words (see Nooteboom, 1969, for a similar argument). The fact that the function words affected by substitutions in the Nooteboom (1969) study were all prepositions, which are among the phonologically least typical of the function words (e.g., they are stressable), appears to support this interpretation.

Children and adults were found to differ with respect to the effect of word class on the occurrence of sound errors. In the adult corpus, function words are underrepresented in the set of words affected by sound errors. In the child corpus, however, a fair amount of errors affects function words. It is important to note that the result for the adults replicates the general pattern reported in the literature, irrespective of language (Nooteboom, 1969; Stemberger, 1984). It can therefore be concluded that the results of the (Dutch) children in this study differ from the *adult* pattern, rather than the *English* pattern.

It has been argued that function words' reduced vulnerability to sound errors is due to their extremely high frequency of use (Stemberger, 1984; Dell, 1990). The effect may be explained by the conjecture that the extremely frequent encoding of the phonological form of function words leads to the emergence of new, specialized processing procedures. The present data, in contrast with these suggestions, suggest that frequency does not affect the vulnerability of function words to sound errors in child speech. The function words hit by sound errors in the present child corpus turned out to belong to the most frequently used words in the sample. However, it is more than likely that irrespective of their high relative frequency, the absolute frequency of these words in child language use is still considerably lower than in adult speech. Arguably, the development of specialized routines for the retrieval of function words needs many more attempts to produce these words than is possible within the life span of a 3-year-old.

Another way to explain the appearance of sound errors in function words in the child corpus is to conjecture that function words in children simply do not yet form a closed class. Dutch, which is probably representative of many languages, has some 700 function words at the most (Van Wijk & Kempen, 1980). Although this number is dramatically small in comparison to the number of content words, it cannot be learned overnight by any child. The child subjects in this study quite plausibly know just a fraction of this set. The upshot is, that as long as a speaker is learning the vocabulary, none of the word classes can be considered "closed." Consequently, if the hypothesis that closed class items are subject to a specialized access procedure (Garrett, 1975) is true, it is not applicable to the function words in the children's corpus. Thus, in the developing speaker, function words may be processed just as content words.

In summary, the results of this study do not seem to point to structural developmental differences in the language production mechanism. Rather, some of the correspondences in the adult and child data, for instance, those with respect to the grammatical constraint on lexical substitutions and the syllable position constraint on subsyllabic sound errors, suggest that some of the basic algorithms in production, e.g., the slot-filler mechanism, are developmentally

invariant. Three major differences between adults and children were found: (1) Error frequency in children is higher than in adults. (2) Word substitutions in children less often involve phonologically similar words than in adults. (3) In children, function words are more often struck by sound errors than in adults. These three differences seem to share a similar background, which may be captured by the term "practice." First, the increased error rate in children was argued to result from a lack of automatization. Clearly, automatization will gradually come about as practicing of the speech production mechanism proceeds. The low proportion of phonologically motivated lexical substitutions was suggested to be related to a restriction on backward spreading of activation. It can be speculated that backward activation spreading from phonological nodes to word nodes may result from prolonged practice in the access of phonological nodes from word nodes, just like sufficient practice in counting will bring about the ability to count in reverse. Finally, the occurrence of sound errors in function words can either be related to a lack of experience in producing these words (i.e., low absolute frequency), or to the fact that these words do not yet form a closed class, as the acquisition of the lexicon is still underway.

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