

Acquisition of Pig Latin: a case study*

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ABSTRACT

A boy's acquisition of Pig Latin was monitored throughout the year preceding first grade. Abilities underlying this game include the identification of words, deletion of the first syllabic onset (i.e. prevocalic consonants) of each word, blending of this onset and the suffix [ei] onto the word's end, and short-term memory for speech units. Performance improved over time as the underlying abilities developed. Meanwhile, various informative errors were made. Throughout most of the study, onsets that were correctly removed from a word's beginning were often added to its end incorrectly; unstressed function words were repeated intact and not transformed; and the first syllabic onset was overlooked when the syllable was unstressed. Because speech games like this one depend upon basic language skills, they can clarify aspects of ordinary language development.

A child's method of carrying out a speech game can reveal his or her conception of the language's units and rules (Sherzer 1970, 1982, Kirschblatt-Gimblett 1976, Morais, Carey, Alegria & Bertelson 1979, Alegria, Pignot & Morais 1982, Cowan & Leavitt 1982, 1987, Cowan, Braine & Leavitt 1985, Treiman 1985, 1986, Content, Kolinsky, Morais & Bertelson 1986). The developmental course of a speech game therefore would seem to be a promising source of information about the acquisition of linguistic knowledge. However, little is known about this aspect of development. Ferguson & Macken (1983: 249) stated that 'In the sizeable literature on play languages which has come to our attention, we have not found a single study in which children's use of a particular play language is followed developmentally'.

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The present paper describes one child's gradual acquisition of a common play language, 'Pig Latin'. The special contribution of this research is that abilities and errors were monitored over a course of acquisition that continued for longer than one year and was driven by the child's strong motivation to succeed.

The previous studies of children's language games differ from the present study in various respects. Cowan & Leavitt (1987) described developmental changes in two children's self-invented ability to 'talk backward' by reversing the order of phonemes. However, in that study it was not possible to observe early stages of acquiring the language game, when informative errors might have been made. Other investigators have examined performance on culturally-transmitted speech games, but they have focused on linguistic and social implications of the fully developed game rather than its course of acquisition (e.g. Sherzer 1970, 1982, Kirschenblatt-Gimblett 1976). Acquisition and errors have been examined in studies of experimentally-taught language games (e.g. Treiman 1985, 1986, Content *et al.* 1986), but those studies have used cross-sectional rather than longitudinal samples. The present study addresses the persisting need to examine the early developmental course of a common language game in childhood.

In order to describe the rules of Pig Latin, it is helpful to introduce the terms ONSET, which refers to the initial consonant cluster of a syllable, and RIME, which refers to the remainder of the syllable. (If a syllable begins with a single consonant followed by a vowel, then this consonant is the onset; if it begins with a vowel, then it has no onset.) Various linguistic and psychological studies indicate that onsets and rimes are especially salient subsyllabic units of speech (see Fudge 1969, MacKay 1972, Halle & Vergnaud 1980). This may be why onsets and rimes are used in language games such as Pig Latin; both adults and children naturally choose to divide syllables between the onset and rime in games in which a division point must be selected (Treiman 1985, 1986).

In the version of Pig Latin that the subject was taught, the onset of the first syllable of each word (if any) is to be shifted to the end of the word, and the vowel sound [eɪ] as in *day* is appended. Thus, the sentence *Please listen to us* [plɪz lɪsn tu ʌs] would be transformed as [ɪzplɪɪ ɪsnɪɪ utɪ ʌsɪɪ]. Children have played Pig Latin and other, similar games for a long time (see Chrisman 1893, Hirschberg 1913).

Because Pig Latin requires knowledge of both intrasyllabic and lexical units and how to manipulate them (see Halle 1962), the study of a child's acquisition might clarify the development of these underlying language skills. Below, the skills will be described in greater detail, and then past research on their development will be summarized. In this way, it will be possible to form general expectations about the acquisition of Pig Latin.

The first step in the acquisition of Pig Latin is simply to learn the rules.

Then, in order to transform an utterance, one must determine what words it contains. Further, to transform each word one must identify the onset of the first syllable, and must be able to pronounce the word with this onset shifted to the end and the suffix [eɪ] appended. Finally, all of the component units (words, onsets and word-remainders) must be retained in memory while they are being manipulated to form the Pig Latin utterance; memory could potentially fail at any point.

In sum, at least five basic abilities appear to be necessary for Pig Latin: (1) understanding of the rules; (2) identification of words within multi-word utterances; (3) segmentation of each word into the first onset and the word's remainder; (4) blending of the onset and the suffix [eɪ] onto the end of each word; and (5) memory for the various components of the utterance during mental transformation and speech production.

Theoretically, two general factors should govern a subject's rate of acquisition of Pig Latin. First, if the subject does not have the abilities that are needed to carry out Pig Latin, the acquisition of the game should be impeded until these requisite abilities develop. Secondly, even when the abilities are fully in place, it might take time to learn to apply them specifically to Pig Latin. Thus, if one could find an intelligent, literate adult who knew nothing of Pig Latin (which could be difficult in our culture), acquisition of the game still might not be instantaneous. However, in the case of a preliterate child it seems likely that most of the difficulty in acquiring Pig Latin would be due to the former factor: the immature status of the requisite abilities. Let us examine, therefore, the likely developmental course of these abilities.

Development of the requisite abilities

The rules. The rules of Pig Latin seem simple enough that even young children should understand them, provided that they can learn to identify the lexical and intrasyllabic units involved and manipulate them as necessary. If the units could be laid out in an unmistakable fashion, the rules of Pig Latin presumably would not be very difficult. The difficulty of Pig Latin presumably is in the underlying skills of speech segmentation.

Identification of words within multi-word utterances. A preliterate child might well have difficulty dividing a multi-word phrase into words to be transformed. Children typically learn to segment phrases or sentences into words only during the early elementary school years (for a review, see Lundberg 1978). Karpova (summarized in Slobin 1966) found that Russian children younger than 7;0 could make binary divisions of a sentence and could identify many nouns as words, but that they underestimated the number of words in a sentence and tended to overlook words such as

prepositions and conjunctions, which might be included in a more general category of 'function words'. Huttenlocher (1964) found that 4-year-old children sometimes could divide simple, two-word phrases into words, but that many errors were made, approaching 50% for word pairs that formed coherent sequences (e.g. *you are*). In both of these seminal studies, one can observe that preliterate children focused on elements of meaning rather than on lexical form, and that they behaved as if the word were not a natural, intuitive unit of speech.

Later studies further confirm and elaborate these conclusions. Holden & MacGinitie (1972) found that function words were often perceived by kindergarten children to be part of the preceding or following word (e.g. *You / haveto/ gohome*). Ehri (1975) found that function words sometimes were articulated separately by the subject but were still omitted when the task was to tap out the number of units, suggesting that there may be multiple levels or types of awareness of lexical units. Finally, Downing & Oliver (1973-4) found that preliterate children classified phonemes or syllables spoken in isolation as words. In one age range (5;6-6;5) they appeared to exclude long words from the definition of a word, presumably because they perceived them as made up of more than one word. Given all of these limitations in the perception of words, it seems likely that a pre-reader would not be able to transform correctly all multi-word phrases into Pig Latin. Notice that a child's attempt to transform a phrase should indicate his conception of its word units.

Transformation of individual words: segmentation and blending. For the transformation of a single word, intrasyllabic segmentation and blending abilities would be most critical. Considerable research suggests that some of these abilities are acquired around the same time as beginning reading (for reviews, see Richardson, Di Benedetto & Bradley 1977, Lewkowicz 1980, Alegria, Pignot & Morais 1982, Fox & Routh 1984, Mann & Liberman 1984, Torneus 1984, Bryant & Goswami 1987, Hulme 1987). However, the rudimentary segmentation skills needed for Pig Latin may develop earlier. Some studies (Lenel & Cantor 1981, Bradley & Bryant 1983, Stanovich, Cunningham & Cramer 1984, Maclean, Bryant & Bradley 1987) indicate that preliterate children generally can learn to detect rhymes. This implies that children are able to perceive the onset and remaining portion of the word separately. In another study (Treiman 1985), children aged 5;6 could identify the phoneme at the beginning of a syllable much more easily when it alone was the syllabic onset than when it was part of a multi-phonemic syllabic onset. Thus, the perception of syllabic onsets appears to developmentally precede perception of individual phonemes.

Despite all of this research, it is an open question whether a pre-literate child should be able to learn Pig Latin. On the one hand, Morais *et al.*

(1979) found that illiterate adults could not perform a task in which the first phoneme of a word was to be omitted, whereas literate children could do this task easily. On this basis one might expect that literacy must be present before one can carry out Pig Latin. On the other hand, there are several reasons to question this assumption. First, Content *et al.* (1986) found that even 4-year-old, preliterate children could learn to delete the initial phoneme in a consonant-vowel-consonant syllable when trained with corrective feedback. Secondly, in Pig Latin one is asked to remove the initial onset rather than the initial phoneme, and this may be a more natural task; research with word-segmentation games suggests that adults and children most naturally divide syllables between the onset and the syllabic remainder or rime (Treiman 1983, 1985, 1986), which is what Pig Latin requires. The children observed by Content *et al.* (1986) may have been successful at initial-phoneme segmentation only because each syllabic onset in their stimuli had only one consonant.

Children's ability to learn to segment the first onset successfully in Pig Latin does not necessarily mean that they should be able to speak words in Pig Latin; completion of the transformation also requires blending of the first onset and the phoneme [eɪ] onto the word's remainder. Although there is evidence that some preliterate children can blend phonemes (e.g. Fox & Routh 1984, Torneus 1984), it is not clear if the level of blending ability would be sufficient for the Pig Latin transformation. The segments to be blended in Pig Latin (e.g. for the word *speaker* [spikə], [ikə] + [sp] + [eɪ] = [ikəspeɪ]) often are more complex than those that have been used in the experimental tasks. Also, these experimental tasks have employed visual markers to aid memory for the sequence of phonemes to be blended together.

Short-term memory. The demands on memory are of course greatest for multi-word utterances that are to be transformed into Pig Latin. Separate parts of the word undergoing transformation must be retained and manipulated at the same time that the entire utterance is held in memory. If a word is long, it might have to be saved as three or more chunks once it is broken up in any way. Memory capacity also may be required to retain the mental schema or 'executive routine' through which Pig Latin is carried out (e.g. see Case 1974). Thus, the memory load imposed in Pig Latin could well exceed the number of words in the phrase to be transformed.

The number of items that can be held in memory increases with age, and this developmental trend has been shown to be based on the increasing speed of mnemonic operations such as covert rehearsal of the list items. When speed is equated across ages by adjusting the familiarity of the material to be remembered, the memory span differences are eliminated (Case, Kurland & Goldberg 1982). Accordingly, there are two reasons why one might expect a child's memory capacity for Pig Latin to increase with age. First, the speed

of some of the relevant mental operations should increase as he matures. Secondly, his continued practice in Pig Latin should further increase the relative speed at which Pig Latin operations in specific are carried out. In support of these possible factors, Cowan & Leavitt (1987) described contributions of maturation and skill-specific practice for two children who engaged in one special language game, 'talking backward'. Similar advances should lead to an increase in the portion of working memory that is free for the retention of multi-word phrases and longer words in Pig Latin.

Because multiple skills are involved in Pig Latin, there is no reason to expect all-or-none acquisition. If various requisite abilities mature at different rates, a gradual course of development with multiple phases of imperfect performance could emerge.

METHOD

The subject

The subject was a boy with whom the investigator interacted almost daily throughout the study. He was 5;3 at the beginning and 6;5 during the last intensive test session, although additional observations up to age 7;2 are reported. He received the Wechsler Intelligence Scale for Children - Revised (Wechsler 1974) at the age of 6;0 and attained a verbal IQ of 137 and a performance IQ of 115. His skill profile in scaled scores was as follows: information, 16; similarities, 16; arithmetic, 11; vocabulary, 19; comprehension, 17; digit span, 12; picture completion, 15; picture arrangement, 12; block design, 14; object assembly, 11; coding, 9; and mazes, 14. (For each score, population mean = 10 and s.d. = 3.) The largest number of digits remembered correctly was 5 forward and 3 backward.

At 5;10, the child took the Metropolitan Reading Readiness Test (Hildreth, Griffiths & McGauvran 1964), which tests for a variety of perceptual coding, knowledge, comprehension and memory skills assumed to be helpful in beginning reading. Although he made only one error on this test, he was still pre-literate. He was enrolled in kindergarten and became familiar with some of the letters of the alphabet there. By the time of his entry into the first grade at the age of 6;5, he knew the letter-to-sound correspondences of most English consonants, but not most vowels. He could read some three-letter words if the vowel was pronounced for him, and he recognised a few words by sight. Reading acquisition progressed normally in the first grade.

Stimuli and procedure

Whenever the subject expressed an interest in talking Pig Latin, words to be transformed were spoken to him in English. In all, 163 different words were presented in isolation during the study. There were also 29 multi-word

phrases (8 with two words, 14 with three words, 5 with four words, 1 with five words, and 1 with seven words). The stimuli are listed in the Appendix. Some stimuli were presented more than once on separate occasions if an error was made on the first presentation. The initial presentations of most of the words and phrases were distributed across 19 test sessions, during which the subject's age increased from 5;3 to 6;3. Fifty-four of these words and 17 of the phrases were presented again when the child was 6;5, on the last two days before first grade. These included most of the items that had resulted in an erroneous response in some earlier session. Finally, 19 additional words and eight additional sentences were presented when the child was 7;2, to help resolve ambiguities in the data.

Each Pig Latin response was recorded using a broad phonetic transcription. (To permit non-phonologists to read Pig Latin transcriptions, the transcriptions of the original words also are given in most cases.) If the child corrected himself, both responses were recorded and counted in the sample. The child was praised following correct responses and gently corrected following erroneous ones. The predominant concern was that the study should remain fun for the child, so as to maintain his interest throughout the period of acquisition. With this in mind, sessions were conducted primarily at the child's request and were terminated while he was still enthusiastic.

Words for the stimulus set were selected largely on the basis of their phonetic properties and level of difficulty. The intent was to include a variety of phonetic combinations, consonant clusters and morphological characteristics within the stimuli and to make them challenging but not discouraging. As the child began to master the basic rules of Pig Latin, longer words and words with more complex phonetic structures were included, as were multi-word phrases. Occasionally, the subject thought of words that he wished to transform, and these responses were also recorded.

RESULTS

Two aspects of the results were considered to be important: the development of ability over time, and the errors that occurred along the way. These will be described in turn.

The development of ability

In the first two test sessions, the subject did not correctly transform any words, even though the investigator explained the rules of Pig Latin and provided some examples. The subject understood the basic rules of Pig Latin by the third session, when he was 5;6. Nevertheless, the ability to correctly transform various words presented in isolation developed much more gradually, as the data in Table 1 suggest.

TABLE 1. Number (*N*) of 1-, 2-, and 3-syllable, isolated-word stimuli and percentages of correct transformation of these words during four age ranges

Age range	One-syllable words		Two-syllable words		Three-syllable words	
	<i>N</i>	% correct	<i>N</i>	% correct	<i>N</i>	% correct
5;3-5;7	34	47.1	11	45.5	7	14.3
5;8-6;0	28	67.9	13	30.8	1	0.0
6;1-6;3	29	79.3	15	60.0	5	0.0
6;5 retest	24	91.7	19	94.7	10	30.0

This table contains both the presentation frequencies for isolated 1-, 2-, and 3-syllable words during four age ranges and the percentages of these words that were correctly transformed. No statistical measure was considered suitable for an analysis of all of the data, but non-parametric statistics were used to compare particular rows and columns of the table. The numbers of correct and incorrect transformations were entered into the analyses as separate columns. (Fisher's Exact Test was used for 2×2 data arrays because of its superior power; for larger arrays, chi-squared tests were used.) The tests indicated that, for one-syllable words, the proportion correct increased significantly across the four age ranges, $\chi^2(3) = 15.00$, $p < 0.005$. This conclusion holds even if the retest session is omitted from the analysis, $\chi^2(2) = 7.38$, $p < 0.025$. The change in proportion correct over age was also significant for two-syllable words, $\chi^2(3) = 15.35$, $p < 0.005$. However, for these words the change was not significant when the retest session was omitted from the analysis, $\chi^2(2) = 2.39$. These results suggest that the improvement in performance may have been more rapid for one-syllable words than for two-syllable words. There were too few stimuli to conduct an analysis of three-syllable words.

A comparison of performance within a particular age range provides further clarification of the trends. The proportion correct was significantly higher for one-syllable words than for two-syllable words in the second of the four age ranges in the table, 5;8 to 6;0 (Fisher's, $p < 0.05$). In contrast, performance on these word types did not differ significantly in any other age range. The proportion correct for two-syllable words was in turn higher than for three-syllable words for the third age range, 6;1 to 6;3 (Fisher's, $p < 0.03$), and for the retest session (Fisher's, $p < 0.001$), but not for the earlier age ranges. One reasonable interpretation of these data is that the subject's ability progressed faster for shorter words. This interpretation is limited by the paucity of data for three-syllable words, but one must bear in mind that additional three-syllable words were not presented precisely because the child was having such difficulty with them. In the retest session,

within-word errors all occurred for multi-syllabic words, with the exception of words with plural endings (for reasons to be explained).

It is noteworthy that the subject did sometimes succeed in transforming the longer words. Early in the study, the words *cigarette* and *popcorn* were correctly transformed. Examples of correctly transformed words also included *caterpillar* at age 6;0, *gasoline*, *hamburger*, and *pretzel* in the re-test session, and *dictionary* and *oriental* at age 7;2.

In the earlier sessions, the subject did not understand how to segment a phrase or sentence into words. Even after he did appear to understand, he continued to incorrectly transform some of them. At ages 6;2 and 6;3, brief sentences such as *Go to sleep* and *I feel good* were first transformed correctly.

The most informative responses seemed to occur when the child was preliterate, and his entry into first grade was selected as a convenient termination point for the intensive portion of the study. However, the Pig Latin utterances that the child subsequently produced (often unsolicited) indicate that his abilities continued to improve. By 6;7, he demonstrated the beginning of the ability to comprehend and engage in Pig Latin conversation. By 6;9, he conversed fluently. Nevertheless, errors continued to occur throughout the study. Some multi-word utterances were still treated as single words, some long words were still treated as multi-word utterances, and within-word segmentation was still incorrectly influenced by word stress (see below).

A taxonomy of errors

In all, there were 162 erroneous responses on words and phrases throughout the study, including responses to stimuli that had been presented more than once on separate occasions. Six types of error accounted for 114 (70.4%) of the errors. These frequent error types and the remaining errors are described below. Table 2 lists the stimuli for which each of the main types of error was made.

Error type 1 ($N = 30$). In these errors, an inappropriately long segment of a word was shifted from the beginning to the end (e.g. *potato* [pəteɪtə] was transformed as [eʔopəteɪ], corresponding to the segmentation *pot.ato*, rather than as [əteɪʔopəteɪ]).

The characteristic that appears to be most important in these errors is SYLLABIC STRESS. A stressed syllable is one that is typically produced with a higher fundamental frequency, greater duration, and greater intensity than if it were produced in an unstressed manner (Sorensen, Cooper & Paccia 1978). The relevance of stress was noticed first for the 5 three-syllable words (excluding words starting with a vowel) for which the Type 1 error category applied. All of them had primary stress on the second syllable and were

TABLE 2. *Stimuli on which errors of types 1-6 were made*

Type 1 (shifted initial segment too long - italics denote word stress)
accident, agua (Spanish, × 2), alphabet, argument, banana (× 2), barrette, bologna (× 2), cadet, confused, correct, gasoline, giraffe, observe, pyjama (× 2), permit (verb), police, potato, reject, remark, return, spaghetti (× 3), suggest, surprise, surround.
Type 2 (one consonant from onset omitted)
2a (one-consonant onset): beer, bite, boxtop, cans, finger, home, hungry, latin, light, loop, milk, nose, paper, pig, the.
2b (two-consonant onset) blue, smile, spot.
Type 3 (interpolation of incorrect phonetic material)
accident, boxtop, crayon, gallon, go, hamburger, hands, ice cream, latin, like, no, the, to, top.
Type 4 (repetition of the initial vowel at the end of the word)
4a ([ei] omitted) beaks, box (× 3), cocky, creepy, go, grow, ho ho ho, ketchup, like, lollipop, Monie, popcorn, shoot, soap, top (× 2).
4b ([ei] included) basket, bite, box, creepy, go (× 2), grow, Jean (× 2), mitten, Nelson (× 2), shirt, soap, truck.
Type 5 (repetition of the initial vowel and subsequent consonant at the end of the word)
5a ([ei] omitted) bamburger, Jello, jingle.
5b ([ei] included) bells, gallup, goodnight, melt, silly, store.
Type 6 (failure to transform function words)
shut the door (× 2), write a letter, clap your hands (× 2), light the candle (× 2), drink your milk (× 2), go to the store.

divided too late in the word (as in the example *potato*, described above); the divisions were *pot.ato*, *bol.ogna*, *spagh.etti*, *pyj.ama*, and *ban.ana*. In contrast, words with three or more syllables and primary stress on the first syllable ($N = 4$) were divided at the correct point, judging by the way in which the transformed word began. This effect of stress was significant (Fisher's, $p < 0.01$). The result is further strengthened ($p < 0.001$) if one accepts responses to all stimulus tokens rather than just unique words, inasmuch as the child's division points were the same when particular stimuli were repeated in separate sessions. Including these repetitions, there were six presentations of words with first-syllable stress, all of which were divided at the correct point, and 12 presentations of words with second-syllable stress, all of which were divided incorrectly.

An hypothesis that may account for the subject's transformation of these multisyllabic words is that he shifted the portion of the word up to and including the onset of the first stressed syllable, rather than shifting the onset

of the very first syllable only, as he should have done. However, this hypothesis has meaning only if one can determine where the division between syllables occurs, which is necessary in order to identify the onset of the second syllable.

There are several principles that appear to be important in the syllabifications that people perceive (see Fallows 1981, Cowan *et al.* 1985, Treiman & Danis 1988). First, there are PHONOTACTIC CONSTRAINTS; phoneme sequences that cannot begin a word cannot begin a syllable either. For example, the syllabifications *e.mpty* or *em.pty* could not occur, because a syllable in English cannot begin with the phoneme sequences [mpt] or [pt]. Secondly, there is a principle of MAXIMAL SYLLABIC ONSET, which refers to a tendency for syllables to begin with as many phonemes as possible. This principle would favour the syllabification *emp.ty*, which contains the maximal allowable onset for the second syllable, over the alternative syllabification *empt.y*. Thirdly, there is a principle of WORD STRESS, which refers to a tendency for stressed syllables to contain as many phonemes as possible. Unlike the maximal onset principle, the word stress principle would favour the syllabification *empt.y* rather than *emp.ty*, given that the word's first syllable is stressed. Finally, there is a principle of AMBISYLLABICITY, which refers to placement of the syllabic boundary within a single consonant when other principles are in conflict. In the word *lemon*, for example, the boundary could fall within the [m] to produce the syllabification *lem.mon*. Although phonotactic constraints operate absolutely, they often allow more than one syllabification, and that is when the other principles come into play. When two or more of the other principles conflict, they seem to compete with one another in subjects' judgements (Fallows 1981, Cowan *et al.* 1985).

Within the words with three or more syllables for which Type 1 errors were made (discussed above), the syllabic boundaries are not controversial. Two of the principles of syllabification (maximal onset and stress) both suggest that the consonant following the first vowel would be perceived as the onset of the second syllable. None of the principles contradict this syllabification. Thus, these data are consistent with the hypothesis that words always were divided after the onset of the first stressed syllable.

The role of stress could not be examined in two-syllable words, because all of these stimuli had primary stress on the first syllable. To compensate for this limitation in the data, 14 two-syllable words with primary stress on the second syllable were presented for the first time when the subject was 7;2. For each of these words, the portion that was shifted was inappropriately long, and included the onset of the second syllable of the original word. In contrast, for the two-syllable words presented throughout the study, which had primary stress on the first syllable (30 different words, 44 total presentations), the division point was always after the initial onset. Thus, the effect of word stress was again highly significant (Fisher's, $p < 0.001$).

In one instance at age 7;2, the same word was presented in two different stress patterns: 'permit [pə'mɪt] (noun) versus per'mit (verb). The child insisted that the former word should be transformed as [ə'mɪtpeɪ] (which is correct), but that the latter word should be transformed as [ɪtpəmeɪ] (which is incorrect).

These responses raised the possibility that the subject actually might not know the correct rule for the Pig Latin transformation. Contrary to this interpretation, though, he correctly stated the rule when questioned directly at the end of the session at age 7;2. Specifically, he said that the first sound should be moved to the end of the word, and that the sound [eɪ] should be added. However, he could not define a sound, and said that he had to 'just listen' to the word to determine what the first sound was. Apparently, he did not analyse unstressed syllables into smaller components; he implicitly considered the word's first sound to be the portion up to and including the onset of the first stressed syllable.

There is one exception to this description of the subject's performance. He apparently did not remember or could not apply the rules of Pig Latin for words that began with a vowel. Only a few were presented, and until 7;2 they all resulted in errors of Type 1. These stimuli, with the subject's division points included, were *acci.dent*, *alpha.bet*, *argu.ment*, and *ag.ua* (Spanish). For example, *accident* [æksədənt] was transformed as [dəntæksəeɪ]. However, by 7;2, the child appears to have understood the rule; he correctly transformed all of the vowel-initial words that had been presented before, and also the new word *oriental*.

Error Type 2 (a & b) (N = 18). In these errors, one consonant from the first syllabic onset was omitted entirely instead of being shifted. Usually, this occurred when there was no cluster and the omitted consonant was the entire onset (*Type 2a*, $N = 15$). For example, *light* [laɪt] was transformed as [aɪteɪ] rather than [aɪtleɪ]. On a few occasions (*Type 2b*, $N = 3$), a consonant from a two-consonant onset was omitted. For example, *smile* [smaɪl] was transformed as [aɪlseɪ] rather than [aɪlsmeɪ]. In one of the three instances, it was the initial consonant of the onset that was omitted: *spot* [spɒt] was transformed as [bæteɪ]. (It is interesting that, in this word, the child apparently perceived the [p] to be a surface manifestation of the underlying phoneme /b/.) There was no example in the data in which a multi-consonant onset cluster was entirely omitted. Inasmuch as the transformation of words usually began correctly within this error type, it does not appear that the main problem was one of segmentation of the word into smaller units.

These errors possibly could result from short-term memory limitations. The subject must remember the initial onset while he pronounces the word's remainder, and part or all of this onset could have been forgotten before it could be added to the end of the word. On the other hand, according to a

short-term memory explanation, one might expect the error type to be especially prevalent among longer words, and that was not the case; multi-syllabic words did not account for as large a proportion of the Type 2 errors as they did within most other error types (see Table 2). This suggests that, if short-term memory limitations did cause Type 2 errors, it was the transformation routine rather than the phonological representation of the words to be transformed that posed the most severe memory constraint.

Error Type 3 (N = 14). In these errors, incorrect phonetic material was interpolated near the end of a word. For example, *Latin* [lætɪŋ] was transformed as [ætɪŋlɪdeɪ] rather than [ætɪŋleɪ].

It is unclear whether these errors should be attributed to short-term memory limitations or to limitations in blending ability. In the former account, the subject would add phonetic material because it was incorrectly inserted in the short-term memory representation of the word. For example, extraneous material from other words could inadvertently intrude into the short-term memory representation of the word being transformed; Drewnowski (1980) has demonstrated that phonetic material from words presented in succession can intrude in this manner, at least in list-recall situations. In the account based on blending, on the other hand, the subject would add in the material as a bridge when he was unable to blend on the sound [eɪ] after the shifted onset.

Error Type 4 (a & b) (N = 33). In these errors the initial onset was correctly removed from the beginning of the word but, at the end of the word, the onset and following vowel were pronounced rather than the onset alone. In *Type 4a* ($N = 18$) the Pig Latin suffix [eɪ] was omitted (e.g. *boxtop* [bɒkstɒp] was transformed as [akstɒpɒ] rather than [akstɒpeɪ]). *Type 4b* ($N = 15$) was the same, except that the vowel [eɪ] was appended after the incorrect vowel (e.g. *Jean* [dʒiːn] was transformed as [ɪndʒieɪ] rather than [ɪndʒeɪ]).

Within the Type 4 errors, the segments added to the end of the word were not always complete syllables of the original word. For example, segments used at the end of a word included [nɛ] from *Nelson* [nɛlsən] and [pɑ] from *popcorn* [pɒpkɔːrn], even though the word-remainders [lsən] and [pkɔːrn] cannot be valid sets of syllables according to the phonotactic principle of syllabification discussed above.

The cause of this error type is uncertain. One possible cause is that, when the subject was unable to blend the appendix [eɪ] onto the shifted onset, he substituted the vowel that originally followed that onset. An alternative possibility is that the subject pronounced the shifted onset and then was unable to stop pronouncing the next segment of the word.

It is worth noting that, in this error type, the onset/rime boundary was preserved at the beginning of the transformed word, but not at the end given

that the first vowel remained attached to the shifted onset. This result does not contradict the research indicating that onsets and rimes are the psychologically real subdivisions of syllables, but it does suggest that these syllabic subdivisions do not fully describe performance in all contexts. In certain circumstances, the subject apparently was compelled to attach the first vowel to the onset, and in those circumstances the rime did not prove to be indivisible. This might be expected according to syllabic theories (Fudge 1969, Halle & Vergnaud 1980) in which the rime is said to be composed of separable 'peak' (vowel nucleus) and 'coda' (final consonant or consonant cluster) subsegments. Additional information about subsyllabic structure can be obtained from Error Type 5, when it is considered in conjunction with the present error type.

Error Type 5 (a & b) (N = 9). In these errors, the initial onset was correctly removed but, at the end of the utterance, the initial consonant-vowel-consonant sequence was appended, either without [eɪ] following (*Type 5a*, $N = 3$) or with [eɪ] following (*Type 5b*, $N = 6$). Among *Type 5a*, for example, *Jello* [dʒɛlə] was transformed as [ɛlədʒɛl] rather than [ɛlədʒeɪ]. Among *Type 5b*, *melt* [mɛlt] was transformed as [ɛltmɛleɪ] rather than [ɛltmeɪ]. In three instances, the segment used at the end did not correspond to a possible syllable in the original word (e.g. [mɛl] is not the first syllable of *melt*, which is monosyllabic.)

There are striking differences between the phonological properties of words that resulted in errors of Type 4 versus Type 5. One difference is in the tense versus lax quality of the word's first vowel (for a list of tense and lax vowels, see Ladefoged 1982: 81). The vowel was lax in only seven out of the 33 Type 4 errors, versus eight out of the nine Type 5 errors, and this difference between error types was significant (Fisher's $p < 0.001$). Another difference was in the quality of the consonant immediately following the vowel. This consonant was a liquid ([l] or [r]) or a nasal ([n], [m], or [ŋ] as in *ring*) in only six out of the 33 Type 4 errors, but in eight out of the nine Type 5 errors, and this difference between error types was significant (Fisher's, $p < 0.001$). Thus, errors of Type 5 characteristically contained a lax first vowel followed by a liquid or nasal consonant (e.g. *jello*, *jingle*), whereas this configuration occurred only once among the Type 4 errors.

This result fits well with known linguistic principles. Stressed syllables in English rarely end in lax vowels, so that it would be most natural for the following consonant to become tightly bound to the vowel. Further, among the consonants, liquids and nasals are thought to be the most closely bound to the vowel, because they are high in vowel-like quality or 'sonority' and therefore tend to form part of the nucleus of the syllable (Ladefoged 1982: 222, and Treiman 1984). These two principles operating in combination would tend to induce the subject to pronounce the postvocalic consonant if

he had incorrectly produced the vowel at the end of the transformed word (which would result in a Type 5 rather than a Type 4 error).

Statistical analyses in which error Types 4 and 5 were combined provide clues to the conditions in which either of these error types occurred. These analyses involved a comparison of errors in which the Pig Latin suffix [eɪ] was included versus those in which it was omitted. First, it was observed that the percentage of [eɪ] omissions increased over time, rather than decreasing as one might expect. When errors were collapsed across Types 4 and 5 and across adjacent pairs of the age ranges shown in Table 1, there were sufficient data for analysis; the increase in [eɪ] omissions was significant (Fisher's $p < 0.001$). The [eɪ] was omitted in eight out of 27 (29.6%) of the errors that occurred by age 6; 1, but in 13 out of 15 (86.7%) of the errors that occurred later.

Why was [eɪ] omitted more often in the later errors? Perhaps because these errors occurred for a different reason than those in which it was included. The [eɪ] was more often omitted for harder words. Only six of the 21 errors in which [eɪ] was omitted were monosyllabic words presented in isolation, whereas 13 of the 21 errors in which [eɪ] was included were of this simple type (Fisher's, $p < 0.04$). The errors in which [eɪ] was included may have occurred most often because the subject had difficulty in blending, so that the post-onset vowel was inserted as a bridge between the onset and final [eɪ]. However, the errors in which [eɪ] was omitted (which tended to occur when the child was older) may have occurred because the post-onset vowel was inadvertently substituted for [eɪ] in these more difficult utterances.

Type 6 (N = 10). This was the single most frequent type of error for multi-word utterances. In these errors, one or more small function word was repeated verbatim, without being transformed. For example, *Drink your milk* [drɪŋk jɔr mɪlk] was transformed as [ɪŋkdreɪ jɔr ɪlkmeɪ] and *Go to the store* [gɔ tu ðə stɔr] was transformed as [ɔgeɪ tu ðə ɔrsteɪ]. Inspection of Table 2 indicates that the non-transformed words included articles, prepositions, and possessive adjectives. These were the stimulus words that were pronounced in an unstressed manner, and the subject may have viewed them as too unimportant to transform. This suggestion will be further elaborated in the discussion section.

By the end of the study, the child overcame this error. First, at age 6; 2 he correctly transformed the sentence *Go to sleep*, even though the word *to* had been overlooked in an utterance presented earlier. At 7; 2, the error had truly disappeared; he correctly transformed *Hit the ceiling*, *Brush your teeth*, *Run for your life*, and *Don't use my hat*.

Remaining errors. Numerous other errors occurred less frequently. Together, they illustrate the complexity of the Pig Latin transformation process and the

many ways in which it can fail. In six instances, the initial consonant was not removed. For example, *sheet* [ʃit] was transformed as [ʃitɪɪ] rather than [itʃɪɪ], and *light* [laɪt] was once transformed as [laɪtbeɪ] rather than [aɪtɪɪ]. In two instances, the consonant was removed but another initial consonant was substituted; for example, *box* [baks] was transformed as [laksbeɪ] rather than [aksbeɪ]. In five other instances, a different consonant was substituted for the shifted onset; for example, *right* [raɪt] was transformed as [aɪtbeɪ] rather than [aɪtɪɪ]. In four instances, the Pig Latin transformation was made correctly but another phoneme in the word was replaced or omitted; for example, *throat* [θrot] was transformed as [oθreɪ] and *paper* [pepə] as [upəpeɪ]. In five instances, a substantial part of the original word was left out. For example, *chandelier* [ʃændəlɪr] was transformed as [ændəʃəl] rather than [ændəlɪrʃeɪ], and *pyjama* [pədʒamə] was transformed as [amədʒeɪ] rather than [ədʒaməpeɪ]. In one instance, there was a mixed decision about whether or not to split a consonant cluster: *plane* [pleɪn] was rendered [leɪnpleɪ] rather than [eɪnpleɪ]. In three instances, the removed consonant cluster (or part of it) was put in the wrong place within a multisyllabic word. For example, *mitten* [mɪtɪn] was rendered [ɪtmɪneɪ] rather than [ɪtɪmneɪ] and trashcan [træʃkæn] was transformed as [æʃkræneɪ] and then [æʃtrækæn], rather than [æʃkæntreɪ]. Finally, in three other instances at 6;5 and 7;2, the sequence of the original word was changed. *Newspaper* [nuzpeɪpə] was transformed as [uzneɪpəpeɪ] rather than [uzpeɪpəneɪ], *feel* [fi:l] was transformed as [lɪfeɪ] rather than [ɪlfeɪ], and *suggestive* [sədʒestɪv] was transformed as [astɪdʒəveɪ] rather than [ədʒestɪvseɪ].

An error type involving plurals first emerged in the retest sessions, although plurals had been treated correctly before. Plurals were reversed morphemically and the plural morpheme was attached to the transformed word (three instances). For example, *bells* [belz] was transformed as [ɛlbeɪz] rather than [ɛlzbeɪ]. There was an earlier, transitional example at age 6;0, in which the plural was represented twice. Specifically, *beaks* [bɪks] was transformed as [ɪksbɪz]. One can probably rule out the alternative possibility that these were responses to the exact phonemic structure of the words, because other words with a CVCC structure were correctly transformed (*milk*, *melt*, *shirt*), as were non-plural words ending in [s] or [z] (*pants*, *nose*).

Few multiword sequences were presented, because the ability to transform multi-word sequences at all came late in the course of acquisition. In three instances, all between ages 5;7 and 5;9, the wrong transformation rule for multi-word segments was applied. For instance, the sentence *zip up* [zɪp ʌp] was at first correctly transformed as [ɪpzeɪlpeɪ], but the child immediately changed his response to [ɪpzlpeɪ]. Apparently, he thought that the addition of [eɪ] was to be applied to the transformed utterance rather than to each word separately. By age 6;2, three-word sentences were usually correctly transformed, except that the child failed to transform function words unless prompted to do so. As noted above, this problem disappeared by age 7;2.

When the child treated a phrase as if it were a single word, he usually also made some other mistake in its transformation. The only exceptions to this occurred in the follow-up session, when the child transformed four phrases in a manner that was correct except that each phrase was counted as a single word: *grow up*, *good night*, *zip up* and *Pig Latin*.

Finally, in accord with Downing & Oliver's (1973-4) observation that children sometimes perceive long words as if they were multi-word utterances, the child responded to the longest stimulus words in this way. At 6;8, the word *supercalifragilisticexpialidocious* was transformed in 2-syllable chunks: [upəseɪ ælɪkeɪ ædʒəlfreɪ... etc]. At 7;2, he refused to respond to this same word, but he transformed *encyclopedia* [ɛnsaɪklopiðiə] as [ɛnseɪ, aɪkleɪ, ɪdiəpeɪ].

Units of segmentation: an examination across error types. Pig Latin requires division of each word into the initial onset and the remainder of the word. However, if any other segment is more salient to the child than the onset is, one might expect that he would sometimes erroneously divide the word according to that segment. The main mistaken subdivision was after the onset of the first stressed syllable rather than the onset of the first syllable when it was unstressed. Phonemes and syllables, on the other hand, were very rarely incorrectly selected as the units of division. First, there were only two instances in which initial consonant clusters were split (*spot* at 5;6 and *plane* at 5;7) although there were 49 stimuli with initial consonant clusters, including instances of *bl*, *br*, *cl*, *cr*, *dr*, *fl*, *fr*, *gr*, *pl*, *pr*, *sl*, *sm*, *sp*, *st*, *str*, *thr* and *tr*. This coherence of the syllabic onset is to be expected on the basis of past research (e.g. MacKay 1972, Treiman 1985). Secondly, out of 95 multi-syllabic words that were presented, only four were divided at what could be considered the syllabic boundary according to the principles of syllabification discussed above, namely four of the five stimulus words that began with a vowel. Thus, the syllabic onset appears to be a unit that is natural enough to be identified with a fair degree of consistency within stressed syllables.

DISCUSSION

In the present study, a preliterate child's ability to analyse and manipulate speech was examined longitudinally, in a natural setting. This type of study is more likely to reveal both the upper bounds of the child's ability and a wider range of errors than would an experimental study, because children in an experimental study would have less time to practice the relevant skills (and possibly less motivation or greater social inhibition). The study has provided a clear demonstration of how a child's performance in a seemingly simple language game may evolve as his grasp of underlying skills develops. The generalizability of the findings across children should be examined in future experimental work.

Perhaps most fundamental to Pig Latin is the ability to identify and shift the initial onset of a word. As one would expect from previous work on the natural subunits of syllables (e.g. Treiman 1983, 1985, 1986), the child generally was able to identify the initial onset, judging from the way that he began words in Pig Latin. However, he did have difficulty when the first syllable of the word was unstressed. He always divided the word after the onset of the first stressed syllable, and he could not easily be trained out of this tendency even at the age of 7;2, when he had completed first grade. If this child is typical in this regard, word stress appears to place a serious constraint on children's segmentation abilities.

This finding does not necessarily imply that syllabic onsets are natural units of speech only within stressed syllables, because there may be more than one level of speech representation. Cowan *et al.* (1985) distinguished between a PHONOLOGICAL representation, which is automatically used for ordinary speech perception and production, and a METAPHONOLOGICAL representation, which is the representation that is consciously accessible to the child and presumably underlies performance in language games. In subjects who were adept in talking backward, Cowan *et al.* found that the two representations were related but not identical. The lower limits of speech segmentation were shared by the two representations, but sometimes details of phonological segmentation used in ordinary speech were unavailable to the metaphonological representation. For example, some subjects acted as if the phone sequence [ks] was a single phoneme when it was represented in a word by the letter *x* (even though the same subjects otherwise consistently manipulated words on the basis of their phonological rather than their written representations). A similar sort of description may be applicable in the present study. The syllabic onset may be a natural unit within all syllables, but the intrasyllabic segmentation may have been available only for stressed syllables within the child's conscious, metaphonological representation.

A role of word stress may also be evident in the child's word-level mistakes in transforming phrases and sentences. Until the age of 7;2, his most frequent error for multi-word utterances was to produce function words (prepositions, articles and possessive adjectives) in their normal fashion instead of transforming them. These words are spoken in an unstressed manner, whereas content words are stressed.

The apparent importance of stress is understandable, given the critical role of stress within child language development. Stress is important for marking the child's meaning in early language productions (Miller & Ervin 1964), and the stress pattern of English words is almost always correctly reproduced in young children's imitations (see Clark & Clark 1977: 383). Gleitman and Wanner (1982: 17-24) have presented a compelling variety of evidence that stress is an important characteristic that young children use to identify word-

like constituents within speech. In fact, they argue that differences between languages in the rate of learning different grammatical devices can be accounted for largely by the principle that stressed components are acquired earlier than unstressed components.

A different view of function words is possible, however. Ehri (1975) rejected the view that unstressed pronunciation is responsible for children's difficulty in the perception of function words, because children could not consistently isolate these words in a segmentation task even when they were trained to repeat sentences in a monotone, with each perceived unit articulated separately and with equal stress. However, the effectiveness of this manipulation is dubious, given that the stimuli were still presented in a normal intonation. Nevertheless, it must be acknowledged that an alternative hypothesis is viable: function words might be perceptually difficult because of their meanings rather than their unstressed pronunciations.

Skills other than word and onset segmentation must be considered if one is to obtain a full understanding of the varied errors in Pig Latin transformation that the child made. First, there were many errors that appeared to result from the inability to blend speech segments together at the end of the transformed word. Thus, in the vast majority of errors that were made, the word was started correctly but finished incorrectly. In response to the ongoing controversy about whether blending skills precede or follow literacy (see Fox & Routh 1984, Torneus 1984), the present evidence suggests that blending skills are not completely intact at the age at which literacy begins.

There were also errors that appear to be attributable, at least in part, to the child's short-term memory limits. The percentages of correct transformation for multisyllabic words lagged behind monosyllabic words, and the ability to transform phrases lagged behind the ability to transform isolated words. The role of short-term memory was not necessarily restricted to these cases, though. Short-term memory also might have played a role in various phoneme deletions and substitutions that sometimes occurred within a transformed word.

Even when the separate skills needed for Pig Latin are mastered, it might be an additional step to successfully combine these skills. The fact that there are many ways in which one can fail when multiple skills must be used helps to account for the rich variety of errors that were observed during the acquisition of Pig Latin. In all, the present work indicates that a longitudinal study of the acquisition of language games can be a useful source of evidence about the development of linguistic rules and knowledge.

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APPENDIX

STIMULI PRESENTED FOR PIG-LATIN TRANSFORMATION

(1) *Isolated-word stimuli*

Accident, agua (Spanish), alphabet, argument, bag, ball, banana, barrette, basket, beaks, beer, belly, bite, blue, bologna, boot, box, boxtop, bread, but, cadet, can, cans, cart, caterpillar, chair, chandelier, child, choke, cigarette, cocky, confused, corn, correct, crayon, cream, creepy, curtain, day, dictionary, door, dreidel, dreidels, encyclopedia, fiction, finger, fingernail, floor, foot, frozen, gallon, gallop, gasoline, giraffe, girl, go, good, green, hamburger, hat, head, how, hungry, Jack, jail, jam, Jean, jello, ketchup, kitty, knee, knob, lamp, Latin, law, leaf, light, like, lollipop, loop, Marsha, melt, milk, mirror, mitten, Monie (nickname), Nelson, newspaper, no, Norbert, nose, nothing, now, observe, oriental, pyjama, pants, paper, penis, permit(n), permit(v), pig, plane, plant, police, popcorn, pot, potato, pretzel, prune, red, reject, remark, return, right, rubber, saw, school, science, see, sheep, sheet, shirt, shoe, shoot, silly, sleepy, slipper, smile, soap, sorry, speedboat, spaghetti, spoon, spot, store, strap, string, suggest, suggestive, supercalifragilisticexpialidocious, surprise, surround, teeth, the, throat, to, tooth, top, trashcan, truck, war, wash, watch, water, window, wire, world, yarn, yes, you, zee, zoo.

(2) *Multiple-word stimuli*

Brush your teeth; Clap your hands; Don't touch my marbles; Don't use my hat; Drink your milk; Go back; Go home; Go to sleep; Go to the head of the class; Go to the store; Good night; Grow up; Hit the ceiling; Ho ho ho; How do you feel; I feel bad; I feel good; I like good ice cream; Jingle Bells; Let's get up; Light the candle; Nelson is fuzzy; Pig Latin; Rubber band; Run for your life; Shut the door; Start the car; Write a letter; Zip up.