Speakers' Access to the Phonological Structure of the Syllable in Word Games

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Most linguists probably would agree that more than one type of evidence is relevant to the linguistic description of syllables and other units of speech. Whereas formal linguistic analyses rely on various phonotactic and morphological properties of the language to help determine what definition of units would simplify the linguistic description the most, that information can be supplemented by methods in which human subjects are to indicate, directly or indirectly, the units of speech that they use. One does run the risk of finding that speakers do not have access to the units for uses other than natural speech, or that the accessible units are influenced by a different set of factors than the ones that influence natural speech. However, the present Parasession is a tribute to the difficulty that linguists have had in agreeing upon a description of the syllable. Given this circumstance, we believe that psycholinguistic methods of inquiry can supplement the purely linguistic methods in important ways, especially if the observed syllabic units turn out to be relatively invariant across different behavioral contexts.

A taxonomy of these psycholinguistic methods would include several varieties, each of which has its own strengths and weaknesses. First, one can simply ask the speaker to syllabify a word or phrase. For example, Sapir (1949) asked a speaker of the American Indian language Southern Paiute to repeat the word [pαβα] (which means "at the water") slowly, with the syllables enunciated separately. The speaker insisted on producing the form [pα.pα], with a medial [p] instead of [β]. Along with linguistic evidence, Sapir was able to realize that the underlying word form did include a medial [p], as the speaker insisted, but with pronunciation rules changing this [p] to [β] in a medial context. Speakers are unaware of the contextually specific rules that they use to pronounce phonemes, but they sometimes can provide information about abstract units or forms underlying speech.

In a second, much less direct psycholinguistic method, one can wait for people to make speech errors, and then one can determine the size and nature of the units that were shifted, replaced, or transposed within those errors (e.g., Fromkin, 1971). This method has the advantage that it does not depend upon subjects' conscious understanding of speech. It has revealed that various-sized units,

including not only syllables but also words, morphemes, subsyllabic units, phonemes, and subphonemic features all play a role in speech. However, the method is not ideal for an in-depth investigation of particular linguistic issues, because one cannot control the characteristics of the words on which speech errors are made. There has been some work in which speech errors have been experimentally elicited through a combination of phonemic and semantic pressures (Motley, 1985), but the purpose of that work was to study the activation of units rather than their linguistic description. The phonemic pressures that are used to evoke the errors within this method could contaminate the data so far as linguistic analyses are concerned.

A third method is more direct than waiting for speech errors, but less direct than simply asking subjects to divide speech into syllables. In this method, subjects are asked to play a word game in which the syllables must be reordered in some way. This method allows the experimenter to control the stimuli without relying upon an explicit, conscious judgment as to the division of the word into syllables. In the word game, the subject's linguistic divisions must be made rapidly and implicitly if the task is to be performed with some virtuosity. There are at least two varieties of this task. In one variety, a relatively large number of naive subjects are brought into the laboratory and tested following minimal training (e.g., Fallows, 1981; Morais, Carey, Alegria, & Bertelson, 1979; Treiman & Zukowski, 1990). This method promotes the generalizability of the results to the population at large. However, the origins of variability in the data may not be clear. It could reflect individual differences in linguistic representation, or it could reflect differences in the way people respond to a novel task and particular individuals' different patterns of guessing when in doubt.

The other variety of the language game provides fewer data, but it can supplement the first type. In it, a small number of willing subjects are examined after they have practiced the task for a relatively long time. Presumably, under this circumstance subjects will have worked harder to arrive at an optimal strategy for playing the game, and the optimal solution might well be one that relies on the psychologically valid units of speech. For example, Sherzer (1970) investigated the phonology of a language spoken by the Cuna Indians of Panama on the basis of a speech game that children in that culture played, in which the first syllable of each word was moved to the end of the word.

Our own data are of the latter type, and involve two subjects who were studied in detail. One source of evidence is an adult woman who has played a syllable-reordering game since childhood

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and can carry out this sort of skill more adeptly than any other person that we know of. The second source is a child who tried to learn Pig Latin over the course of a year, when he was still preliterate. Pig Latin does not require an analysis of speech into syllables, but syllable-based errors were often made. In our presentation, we will focus on our own data from these two subjects, but an overarching message is that the evidence from the various psycholinguistic methods of examining syllables, with their different strengths and limitations, is basically consistent. This convergence of evidence across methods lends credence to the hypothesis that they might increase our understanding of syllables on an abstract, linguistic level.

Let us start with the adult woman who reorders syllables. Our knowledge of her arose from a prior study (Cowan, Leavitt, Massaro, & Kent, 1982) in which we examined the ability of a 31-year-old philosophy professor to rapidly talk backward, which he accomplished, it turned out, by reversing the order of abstract phonemic units. For example, *negotiating for peace* would be spoken in reverse as [gɛnitɛʃogɛn rɔf sip]. The publicity generated by this study led to our being contacted by about 50 other backward talkers from around the United States and from other countries. About half of them reversed a phonological representation of each word, and the other half reversed an orthographic representation. All of them believed that they began this game in late childhood, generally between 7 and 11 years of age. This was also the case with the woman who rearranged syllables, although she was unique in terms of the form of her language game. The detailed evidence for phonological representation on the basis of a subset of these special subjects, including the subject who rearranged syllables, was reported previously (Cowan, Braine, & Leavitt, 1985).

Although the group of backward talkers who reordered a phonological representation is not strictly relevant to the issue of syllables, it is helpful to consider for a moment the relation between natural speech and language games that emerged from a consideration of that group. We could tell that the basis of their skill was phonemic rather than orthographic because they did not pronounce silent letters that appeared in the written forms of the words, and because homographs like the two *g*'s in the word *garage* were always pronounced differently. (Specifically, *garage* was reversed as [ʒarɛg].) Moreover, it was clear that these subjects were not functioning as reversed tape recorders. Compound units such as the diphthongs [aɪ], [ɔɪ], and [aʊ] and the affricates [dʒ] and [tʃ] were consistently preserved as units rather than being reversed. For example, the word *choice* [tʃɔɪs] would be [sɪɔtʃ] in a reversed tape

recording, but the subjects reversed it as [sɔɪtʃ] instead. Because the stated aim of these subjects was generally to function as reversed tape recorders, their failure to do so reflects phonological constraints on their acoustic analytic capabilities. Importantly, these constraints are consistent with the phonemic analyses of many modern linguistic theories. Further, it appears that at least some of the subjects' limitations in phonemic analysis were language-specific rather than universal. In particular, two German backward talkers reversed the diphthongs, unlike the native English-speaking backward talkers. In general, it can be said that people carry out word games like this one by manipulating units of speech, and that the games are informative because subjects are compelled to perform these manipulations on units that are psychologically valid.

The woman who rearranged syllables had a standard set of three reorderings that she always produced in a fixed order, in rapid succession. In the first of these, she would reverse the order of syllables, but would keep the order of phonemes within each syllable in the forward order. In the second reordering, she would produce the syllables in their forward order, but with the order of phonemes within each syllable reversed. In the third reordering, she would reverse the order of phonemes from the end of the utterance, without regard for syllables. For example, the word *basket* ['bæskɛt] would be reordered as

['kɛtbæs, 'sæbtɛk, 'tɛksæb].

The utterance *urban and rural cultures* ['ɝbɪn ænd 'rʊrl̩ 'kʌltʃɚz] was reordered as follows:

[ˌtʃɝzkʌlʔəlˌrʊrʔænd'bɪnʔɝ]
[ˌrʊnɪbdnɛˌrurlə'lʌkzrʊtʃ]
[ˌzrʊtʃlʌkləˌrurdnɛ'nɪbrʌ]

In the first two of this woman's three methods of reordering, she has to decide where to place the division between syllables. For example, her solution for the word *basket* (see above) makes clear that the division was [bæs.kɛt]. If the division were *[bæ.sket], it would have led instead to the production of *[skɛtbæ, æbtɛks, tɛksæb]. We presented to this subject a corpus of 230 words and 37 sentences and phrases to reorder, in a number of separate recording sessions.

The solutions that were given almost always implicated the same syllabification rather than two conflicting syllabifications for the different reorderings of a word on a single presentation. On the other hand, there were occasi
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other hand, there were occasional discrepancies between reorderings for the same word when it was presented twice in different test sessions (e.g., *solo* as [sol.o] vs. [so.lo], *sugar* as [ʃʊ.gɝ] vs. [ʃʊg.ɝ], and *pretzel* as [prɛts.əl] vs. [prɛt.səl]). This suggests that the subject did not base her responses on some sort of memorized syllabary, but rather that she rapidly performed a syllabic segmentation when the word was presented. In support of this idea, she did tell us that her method of reordering depended upon the way in which the stimulus words were pronounced.

This woman said that she began to play this speech game at around 8 years of age. Like most of the other backward talkers, she thought that the skill came to her naturally and easily. She developed the game privately, kept it to herself, and did not know anyone with a similar or comparable skill. Given this history, it seems likely that the syllabifications that our subject decided upon were those that she found to be easily manipulable.

Most linguistic theories define the number of syllables in a similar manner, by counting peaks in the sonority or audibility of the sounds within an utterance. However, the theories differ a great deal in how they determine where the boundaries between syllables are to be placed. Therefore, it is of considerable interest to determine the locations of syllabic boundaries decided upon by a native speaker. Our finding was that the syllabifications were orderly and conformed to a number of previously defined principles of syllabification.

The first is the principle of phonotactic constraints. Any sequence of phonemes that would be illegal within a monosyllabic English word can be considered illegal within a syllable, as well. For example, in the word *evening* [ivnɪŋ], the phonemes [v] and [n] cannot be in the same syllable, because English words do not begin or end with a [vn] sequence. Therefore, only one syllabic division is possible: [iv.nɪŋ]. Our subject's reorderings of English words and phrases always conformed to this principle of syllabification.

There are other principles that do not hold absolutely, but do appear to exert pressures that affect syllabification. One of these is the principle that stressed syllables attract phonemes. One clear type of example of this in our own data was with word pairs in which a suffix shifted the pattern of word stress. For example, the word *telegraph* has a stressed first syllable, and it was syllabified as [tɛl.ə.græf], with the [l] sound included in the first syllable. In contrast, the word *telegraphy* has its stress on the second syllable, and it was syllabified as [tɛ.lə.græ.fi], with the [l] shifted to the second syllable. This type of effect of stress on syllabification occurred within

other word pairs of this type also (e.g., for the [t] in *photograph* vs. *photography*).

Syllabification was also affected by the vowel quality in combination with stress. This probably occurred because people do not like to end stressed syllables with a lax vowel. Thus, the tendency would be to syllabify a word like *father* as [fɑð.ɚ], with the first syllable closed. In contrast, if the first vowel of a stressed syllable is tense, as in the word *sofa*, the tendency is to leave the first syllable open, resulting in the syllabification [so.fɑ]. If the first syllable is unstressed, which neutralizes the distinction between a tense and lax vowel, the tendency is again to leave the first syllable open. For example, the word *machine* would be divided as [mə.ʃin] according to these considerations. All of this is in accord with the fact that few words in English end with stressed, lax vowels.

Before we can adequately quantify our subject's responses with respect to vowel quality and syllabic stress, there are two other factors that have to be considered. One is that there was a strong tendency to preserve the morphological structure of the word. Our subject received 31 words in which a division could be placed either at a morpheme boundary or elsewhere without violating phonotactic constraints, and she preserved the morpheme boundary in 27 of these 31 words. An inspection of the examples showed that morphological boundaries were generally preserved regardless of the vowel quality and stress. For example, the word *finalize* was syllabified as [faɪn.əl.aɪz], with the [l] attached to an unstressed vowel, whereas it would be more likely for the [l] to be included in the last syllable instead if it were not for the morphemic nature of the suffix *ize* [aɪz].

A second factor that has to be considered is geminate spelling. When a word was spelled with a double consonant, our subject almost always divided the word in the middle of the consonant, so that the same consonant was included in two syllables. For example, the word *balloon* was divided as [bəl.lun]. This syllabic division within a consonant may occur because there are different principles that pull the medial consonant toward the first versus the second syllable. Indeed, many believe that the primary function of the geminate consonant spelling is to reflect the presence of a phoneme in two syllables. Our subject did occasionally make ambisyllabic responses in cases in which the spelling was not geminate, also. For example, she divided *elephantitis* as [ɛl.ə.fənt.taɪ.tɪs], with the first [t] ambisyllabic. In this example, notice that the ambisyllabicity serves the purpose of preserving the morphological unit *elephant*, in a situation in which the [t] consonant otherwise would have been attracted to the word ending.

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There are many other cases in which an ambisyllabic response could have helped to resolve two conflicting principles of syllabification, but the relative rarity of this type of response in our subject's speech, other than in cases of geminate spelling, could have reflected her view of the task. In a posttest interview, she mentioned that she felt obliged to "get rid of a speech sound once it was used," the effect being that she did not use ambisyllabicity nearly as often as she would have liked to.

Now we can usefully return to the effects of stress and vowel quality. In order to quantify these effects, we omitted cases in which there was a morpheme boundary or a geminate spelling that could influence the results, and we just examined first syllabic divisions, where we had by far the largest number of stimulus examples. For this analysis, in fact, we only included words that had just one consonant at the first syllabic boundary. There were 27 such words in the sample with a stressed, lax vowel in the first syllable; 28 words with a stressed, tense vowel; and 17 words with an unstressed vowel. When there was a stressed, lax vowel in the first syllable, that syllable was left open only 33% of the time. In contrast, when the first syllable ended in a stressed, tense vowel, it was left open 75% of the time, and when the first syllable was unstressed, it was left open 100% of the time.

It is worth noting that there are other studies in which a larger number of subjects have been taught to carry out language games that require syllabification (Fallows, 1981; Treiman & Zukowski, 1990). The results of these studies generally are in good agreement with our own results, except that these naive subjects used ambisyllabicity somewhat more often than our subject did.

The ambisyllabic responses in these studies presumably occurred because two or more principles of syllabification were in conflict. For example, some investigators (e.g., Fallows, 1981) have discussed a principle whereby as many consonants as possible are attached to the beginning of a syllable rather than the end of the previous syllable. This is termed the "principle of maximal onset." This principle would encourage the placement of the medial [f] in the word *sofa* in the second syllable. In this example, stress and maximal onset are in conflict, which theoretically could result in an ambisyllabic treatment of [f].

Another principle of interest is one that involves the sonority contour. A rating of sonority or audibility would be highest for vowels and lowest for stop consonants, with glides and liquids intermediate in sonority and fricatives either intermediate as well, or else equal to stops. Treiman and Zukowski (1990) found that some syllabifications

that previously had been attributed to the principle of maximal onset actually involve the sonority contour. Subjects appeared to prefer syllabifications that resulted in an inverted-U shape for the sonority changes within a syllable (i.e., syllabifications that allowed each syllable to rise steadily in sonority until the central vowel was reached, and then to decline steadily in sonority until the end of the syllable was reached). According to this principle, syllabifications would differ for bisyllabic words with medial ([s] + stop), as in the word *estate*, versus words with other medial consonant pairs, such as (stop + [r]) as in the word *Madrid*. In the case of ([s] + stop), the entire cluster should not be assigned to the second syllable, because in that case the sonority contour of that second syllable would decrease or remain flat when going from [s] to the stop consonant. Accordingly, these investigators found that words like *estate* were usually syllabified with the cluster split (e.g., [ɛs.tet]). In contrast, words like *Madrid* were usually syllabified with the entire cluster assigned to the second syllable (e.g., [mə.drɪd]).

A re-examination of our own data from the woman who reordered syllables indicates that she was consistent with Treiman and Zukowski (1990), and this was true for a wider variety of words than they used. The first medial cluster was split in the words with an [s] + stop: *mister*, *mistake*, *Easter*, *question*, *frustrate*, and *suspicious*. In contrast, the first medial cluster was assigned to the following syllable in other words: *asleep*, *liquid*, *algebra*, *eloquent*, and *ludicrous*. (In the last two cases, the cluster occurred between the second and third syllables.) Other than morpheme boundaries, there was only one exception that we could find to this pattern: the medial cluster was split within the word *apron* [eɪp.rən]. Notice that in this instance, both syllables still had an inverted-U-shaped sonority contour. It may be noteworthy that this well practiced subject followed the linguistic principle with less variability than in the means obtained from naive subjects by Treiman and Zukowski (1990).

It should be mentioned that the sonority contour principle cannot account for everything that has been attributed to the maximal onset principle. For example, it cannot determine what syllabification will result when there is a single medial consonant, as in the word *solo*.

There were at least 7 instances in which the principles that we have discussed could not fully account for our subject's syllabification. These are cases that had a stressed first syllable with a tense vowel, but were still not left open in the syllabification. We believe that in some or all of these cases, the first syllable may have had morphemic value to the subject, although it would not be a standard

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To sum up, our subject's self-determined syllabic boundaries revealed the likely involvement of a number of constraints. There were phonotactic constraints that were obeyed absolutely, and additionally there were influences of morphemic structure, syllabic stress, vowel quality, maximal onset, and sonority contour that could summate or compete with one another. Each of these factors might be expected on the basis of other linguistic and psycholinguistic work, although there may be no single linguistic theory that would have predicted all of the findings.

Now let us turn our attention to the second special subject relevant to the psychological description of syllables. The subject was a bright and linguistically capable boy who was studied (Cowan, 1989) throughout his kindergarten year. At the beginning of the study, when he was 5;3, he was taught the rules of Pig Latin and was given some examples. In 19 test sessions spaced at irregular intervals throughout the year, he was given 163 words and 29 multi-word phrases to transform. Many of the original stimuli were presented a second time and some additional words and sentences were presented, at various ages up until 7;2, in order to chart the course of development and resolve some ambiguities in the data. To our knowledge, this is the first study of the developmental acquisition of a conventional speech game.

The sessions were always started at the child's request and terminated while he was still enjoying the game, so that interest in Pig Latin would not be lost. The child appeared to understand the rules of Pig Latin by the third session, at the age of 5;6, and at that time he could explain these rules to the investigator. Nevertheless, he made a variety of errors in his Pig Latin transformations, even though he was praised for correct answers and gently corrected following incorrect ones. These errors provided evidence about what linguistic units and dividing points were most accessible to him at this point in his development. An older child might well learn Pig Latin without making errors, but this subject was pre-literate throughout most of the study, so that he had only his intuitions about the spoken language to rely upon. As his reading skills began to improve, his intuitions about Pig Latin changed as well.

The rules of Pig Latin are as follows. One is to remove the first consonant cluster, or the first consonant if there is no cluster, and pronounce that consonant or cluster at the end of the word, followed by the sound [eɪ] as in the word *day*. For example, the word *spring* would be transformed to [ɪŋspreɪ]. The child was simply told to move

the first "sound" to the back of the word and add [eɪ], and the meaning of the term "sound" was clarified through examples.

Unlike our first special subject, whose skill was primarily relevant to the issue of the boundaries between syllables, errors in Pig Latin are more relevant to the issue of the internal structure of syllables. Previous linguistic work, as well as research with language games, suggests that the natural major subsections of a syllable are its "onset" and "rime" (Fudge, 1969; Treiman, 1986). The onset is the initial consonant or consonant cluster, and the rime is the vowel along with the final consonant or consonant cluster. In turn, the rime can be further divided into the "peak," or vowel nucleus of the syllable, and the "coda," or final consonant or consonant cluster. However, the peak is more closely associated with the coda than with the onset, so that the structure of the syllable is hierarchical. In these terms, Pig Latin involves shifting the onset of the first syllable to the end of the word.

On one- and two-syllable words considered together, the child's performance increased from just under 50% correct in the early sessions to over 90% correct a little more than one year later, at the age of 6;5, when literacy was beginning. Thus, in many instances, the subject was able to correctly shift the location of the onset of the first syllable. There were 49 stimulus words with a wide variety of initial consonant clusters, but there were only 2 instances in which these clusters were incorrectly split instead of being removed as an onset unit.

At the age of 6;5, performance on three-syllable words was still only at 30% correct, suggesting that the need to remember a long word while manipulating its parts was difficult. Nevertheless, within the next few months he acquired the ability to converse fluently in Pig Latin, except for the longer words and some persistent errors.

There were a number of error types, but only a few of them seem relevant to the psychological structure of syllables, and those are the ones we will discuss. In one frequent type of error, an inappropriately long portion of the word was shifted to the end. For example, the word *potato* should have been transformed as [ɐteɪɾopeɪ], but instead, it was transformed as [ɐɾopɐteɪ]. An inspection of these errors indicated that the child was erroneously taking word stress into account. When the first syllable was unstressed, he skipped over that syllable and divided the word after the onset of the first stressed syllable. Thus, instead of dividing *potato* after [p], he divided it after the first [t]. It proved to be impossible to train him out of this error; he apparently considered

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the word's first "sound" to be the point up to and including the onset of the first stressed syllable. This suggests that, at least in preliterate subjects, unstressed syllables are much less salient units than are stressed syllables. Even at the age of 7;2 this error was still made. At that age the noun *'permit* was transformed correctly, as [ɝmɪtpeɪ], but the verb *per'mit* (with its stress on the second syllable) was transformed instead as [ɪtpɝmeɪ]. This role of stress in making a syllable salient is reminiscent of the function of stress in attracting boundary phonemes, which was observed in the woman who reorders syllables and also has been noted in much of the other research with language games.

Another possible role of stress was seen in the transformation of multiword utterances throughout most of the study. Specifically, the small, unstressed function words were recited in the intact, forward order rather than being transformed. For example, *Drink your milk* was transformed as [ɪŋkdreɪ jɚ ɪlkmeɪ], with the word *your* not transformed, and *go to the store* was transformed as [ogeɪ tu ðə ɔrsteɪ], with *to* and *the* not transformed. It is quite likely that stress plays an important role in children's segmentation of speech into units (see Gleitman & Wanner, 1982, pp. 17-24 for further evidence of this principle).

In another type of error, the onset of the word was removed correctly but too long a portion was recited at the end of the transformed word, either with or without the final [eɪ] sound. These errors may have occurred because the child would have had difficulty blending the onset alone with the suffix [eɪ], or simply because he forgot to halt his pronunciation of the shifted portion at the correct point. In any case, it was the nature of those overly long word endings that was relevant to syllabic structure. In some instances, it was a consonant-vowel-consonant (CVC) sequence that was recited at the end. For example, *Jello* was transformed as [ɛlodʒɛl] instead of [ɛlodʒeɪ], and *melt* was transformed as [ɛltmɛleɪ] instead of [ɛltmeɪ]. In other instances, it was just a consonant-vowel (CV) sequence that was recited at the end. For example, *boxtop* was transformed as [ɑkstɑpbɑ] rather than [ɑkstɑpbeɪ], and the name *Jean* was transformed as [indʒieɪ] rather than as [indʒeɪ]. These CV or CVC portions recited at the end typically were not entire syllables; for example, [mɛl] is not a possible syllable of *melt* and [bɑ] is not a possible syllable of *boxtop*.

What is of the greatest interest here is that the recitation of a CV versus a CVC sequence from the beginning of the word at the end of the transformed word was related to two phonological properties of the words. First, among the cases in which a CVC sequence was

produced, the vowel of this sequence was lax 89% of the time. In contrast, among the cases in which a CV sequence was produced, the vowel was lax only 21% of the time. Thus, the subject usually left the sequence open, rather than including the following consonant, only if the vowel was tense.

Second, the type of consonant following the first vowel made a difference in these types of errors. This consonant was a liquid ([l] or [r]) or a nasal ([n], [m], or [ŋ] as in *ring*) in 89% of the instances in which a CVC sequence from the beginning of the word was produced at the end, but only 18% of the instances in which a CV sequence was produced. These differences are to be expected because of the greater sonority of liquids and nasals than of most other consonants, such as stop consonants and fricatives. The greater the sonority, the more tightly bound the consonant may be to the nuclear vowel of the syllable (Ladefoged, 1982, p. 222). Thus, once again, there is a striking parallel between the syllable-related properties of transformed speech in the two subjects whose language transformations we have described.

Finally, there were errors that revealed the role of morphemes in speech segmentation. One interesting error type emerged for the transformation of words with a plural suffix during the retest sessions, although plurals had been transformed correctly at an earlier age. In these errors, the singular form of the word was transformed and then [s] or [z] was added. For example, the word *bells* was transformed as [ɛlbeɪz] rather than as [ɛlzbeɪ]. An interesting error also emerged that suggested that there may be sequences of morphemes that are loosely associated, but still separate. In particular, the phrase *zip up* was transformed as [ɪpzʌpeɪ]. Notice that the suffix [eɪ] was placed at the end, suggesting that the phrase was treated as a single unit, but that the [z] was placed after the first syllable, suggesting instead that the phrase was treated as two units. Although the role of morphemes cannot be observed in any great detail in this corpus, it is clear that both syllable structure and morphology have to be considered in order to understand this child's interpretation of Pig Latin.

In summary, we have reviewed corpora of evidence from two very different types of language reordering. There are some striking similarities between the two, and together they paint a rather coherent picture of the mental representation of syllabic structure. At least the following 7 principles appear to hold:

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(2) Speech is divided into syllables in such a way that morpheme boundaries are usually preserved.

(3) In literate subjects, spelling is sometimes also taken into account, although the spelling is itself correlated with relevant phonological properties.

(4) The pattern of stress influences syllabification. In particular, stressed syllables tend to attract boundary consonants, and the structure within syllables is more transparent for stressed than for unstressed syllables.

(5) Vowel quality plays a role in syllabification. There is a strong tendency not to end a syllable in a stressed, lax vowel.

(6) Syllabification is accomplished with respect to the pattern of sonority, with an attempt to preserve a simple inverted-U contour of sonority across each syllable.

(7) Finally, at least when the other principles cannot explain syllabification, the principle of maximal onset often can account for it.

These principles from two special subjects with language games are consistent with evidence from other psycholinguistic sources as well. Take, for example, MacKay's (1972) analysis of speech errors in English and German. He focused on cases in which two words with related meanings had been blended (e.g., the words *began* [bigæn] and *started* [startəd] might accidentally be combined to form "*begarted*" [bigartəd]). MacKay found that the majority of divisions occurred at syllabic boundaries, as determined by two native informants, rather than within syllables, confirming the psychological validity of syllables as units. Morpheme boundaries usually coincided with syllable boundaries so defined. Moreover, among blends in which syllables were divided, the division most often occurred before rather than after the vowel. This is presumably the case in our example, "*begarted*," in which the second syllable of the blend includes the [g] from *began* and then the [a] from *started*. On the basis of the corpus of errors, MacKay proposed that syllables can be broken down into organized subunits that others have termed the onset and rime.

Evidence from other types of speech errors further substantiates the psychological validity of syllabic units. For example, phonemic transposition errors usually involve switches between phonemes or sequences that occupy comparable slots within different syllables (see Fromkin, 1973). That is, two onsets may be transposed or two final consonant clusters may be transposed, but an onset and a final consonant cluster are rarely transposed with one another. Finally, there are cases in which morphemic structure is imposed on

syllables. In one example reported by Fromkin (1971), the phrase *bloody students* [blʌdi studənts] was misspoken as [blʌdənt studiz], with the plural morpheme remaining on the last syllable rather than migrating forward along with the rest of the syllable to which it had been attached. This is closely comparable to the way in which Cowan's (1989) child subject at one stage of acquisition applied the Pig Latin transformation to a pluralized noun and then attached the plural morpheme to the end of the transformed noun.

In conclusion, to understand syllables in light of these sources of behavioral evidence, it seems helpful to reconsider the distinction between competence and performance that has been so important within the field of linguistics. Whereas linguists have not been able to agree on the definition of the syllable, there is a fairly high level of agreement among disparate sources of performance data on syllables. Consequently, we believe that the theoretical question need not be whether performance data are relevant to an understanding of speakers' underlying competence; rather, the main question is what type of competence could lead to such relative consistency in performance.

On the other hand, the picture that emerges is not one of total invariance in syllabic representation across behavioral contexts. There would appear to be developmental changes in syllabic representation as phonology is differentiated from suprasegmental cues, as the morphological system is refined, and as written language is acquired (Cowan, 1989; Cowan et al., 1985). Even within a single developmental level, differences between speakers seem likely (see Fallows, 1981; Sherzer, 1970; Treiman & Zukowski, 1990) and, of course, many have spoken of possible language differences in the role of syllables. The present work has identified some areas of stability across behavioral contexts, and the remaining task is to determine which of these areas of stability reflect truly invariant aspects of syllabic representation.

NOTES

Those who would like to receive a copy of a demonstration of several backward talkers (including the woman who reordered syllables) should send a blank audiocassette tape to Nelson Cowan, Department of Psychology, University of Missouri, Columbia, MO 65211. Email address: psycowan@umcvmb.missouri.edu.

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