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Prosodic and Morphological Effects on Word Reduction in Adults: A First Report [1]

Allyson K. Carter and Cynthia G. Clopper

Speech Research Laboratory
Department of Psychology
Indiana University
Bloomington, Indiana 47405

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Prosodic and Morphological Effects on Word Reduction in Adults: A First Report

Abstract. Several populations, such as normally developing children around the age of two years, children with language impairments, and adults with aphasia, all share a similar documented phenomenon in their language production: omitting syllables from their speech. Omitted syllables are most often those that are weakly stressed and that directly precede the primary stress of a word, yielding such stress-initial forms as *nána* for *banána* and *ráffe* for *giráffe*. This phenomenon is reflected in the English prosodic system; that is, in a polysyllabic word, primary stress most often occurs on the initial syllable. It follows that a stress-initial prosodic pattern would be the most common input that children perceive, and therefore learn to produce first, and also the stress pattern that impaired populations would default to when having difficulties in producing less frequent stress patterns. The question explored in this research is whether normal adults' language production also mirrors these facts. That is, do adults, in conditions under which they might reduce words by omitting syllables, also default to these similar patterns? Participants in this study were asked to listen to a list of words and repeat them in a reduced form (as in *Indianapolis* ~ *Indy*, *rhinoceros* ~ *rhino*). Certain prosodic patterns were controlled for in order to systematically examine their effects on reduction patterns. Stimulus words contained two, three, or four syllables, with primary stress on the first, second or third syllable. Results suggest that syllable number and stress do in fact affect how adults reduce words, although it is clear that the relationship between these factors is complex.

Introduction

Word reductions are a deceptively common phenomenon in language. Although they are often found in normal adult speech in the form of word abbreviations, they have been most systematically studied in the productions of normally developing young children, as well as children and adults with language disorders. For example, it is widely known that children with normally developing language, around two years of age, reduce or simplify their words, as in *banána* to *nána* and *giráffe* to *ráffe* (examples from Gerken, 1996; Klein, 1981).

Research on these reductions shows that by and large, children reduce words by omitting syllables in certain predictable patterns. For example, children omit unstressed syllables more often than stressed syllables, and they omit unstressed syllables that precede main word stress as in *banána* or *giráffe* more often than those which follow main word stress (Allen & Hawkins, 1980; Carter, 1999; Carter & Gerken, 1998; Demuth, 1995, 1996; Fee, 1996; Gerken, 1994a, b, 1996; Klein, 1981; Wijnen, Krikhaar, & den Os, 1994). The output prosodic pattern of these truncations often corresponds to a prosodic foot, that is, either a trochee (a disyllabic word with stress on the first syllable) as in *mónkey*, or a monosyllabic foot as in *dóg*.

Several researchers have argued that the reason for these output patterns and consequent syllable omissions lies in the statistical properties of the English language. In an analysis by Cutler and Carter (1987) of approximately 20,000 English words, 90% of content words were found to begin with a stressed syllable. These results suggest that the input that children perceive most often contains a trochaic stress pattern. This stress-sensitive disyllabic foot is one of the earliest prosodic structures that English-speaking children produce, after passing through the monosyllabic stage, and it is therefore considered their Minimal Word (Demuth, 1996; Fee, 1996; Gerken, 1996). Words with weakly stressed, word-initial unfooted syllables as in *ba-nána* are therefore often reduced to a Minimal Word by an omission of the initial syllable (Demuth, 1996; Gerken, 1996; Salidis & Johnson, 1997; Stemberger & Bernhardt, 1997). Other arguments have been made that children's perceptual systems have a strong bias to detect the more perceptually salient properties of stressed syllables and word-final syllables, ignoring any pre-tonic weak syllables (Echols, 1993; Echols & Newport, 1992). Although stress and syllable position are key factors influencing reductions, there are others as well, such as the segmental content of the word (Kehoe & Stoel-Gammon, 1997), number of syllables in an utterance (Gerken, 1996), and lexical familiarity of the utterance (Boyle & Gerken, 1996; Ohala & Gerken, 1997).

The phenomenon of syllable omission has also been reported in several clinical populations with language disorders, such as children who have Specific Language Impairment (Chiat & Hirson, 1987; Leonard, 1998), and adults who have acquired aphasia (Blumstein, 1973; Goodglass, Fodor & Schulhoff, 1967; Nickels & Howard, 1999). Again, these populations tend to reduce words with less frequent stress patterns to the more frequent, stress-initial forms by omitting unstressed, and often initial, syllables. As with normally developing children, however, word reductions in these populations are also influenced by other factors such as segmental content and syllable type (Blumstein, 1973; Carter, 1999; Jakobson, 1963).

In order to better understand the nature of these word reductions in children with normally developing language, children with language disorders and adults with language disorders, we must complete the paradigm by examining what behaviors normal adults exhibit with regard to reductions. In adult speech, word reductions are found most commonly in casual to fast speech registers, as in *cáuse* for *becáuse* and *cámra* for *cámera* (Dalby, 1984; Fisher & McDavid, 1973; Kypriotaki, 1970; Zwicky, 1972), and in word abbreviations and slang, as in *rhíno* for *rhinóceros* or *Bécca* for *Rebécca* (Bareš, 1974; Hamans, 1996; Hodge & Pennington, 1973; Kreidler, 1979; Streeter, Ackroff & Taylor, 1983). In casual and fast speech, reductions are most often formed by medial vowel deletion (syncope) as in *cámera ~ cámra* and *ópera ~ ópra* (Dalby, 1984; Zwicky, 1972), and unstressed initial syllable deletion (aphaeresis) as in *becáuse ~ cáuse* or *afráid ~ fráid* (Fisher & McDavid, 1973; Kypriotaki, 1970). Word abbreviations are formed most often by whole syllable deletions, either word-initial pre-stress syllable deletion as in *Rebécca ~ Bécca* (Hamans, 1996) or post-stress syllable deletions as in *rhinóceros ~ rhíno* (Hamans, 1996; Kreidler, 1979). In addition, although Hamans found that reductions do not necessarily take place at morpheme boundaries, Hodge and Pennington provide evidence that affixes are commonly the deleted elements.

While word reductions are frequent in English and certain large-scale patterns have been reported in surveys of speech corpora, few researchers have performed systematic experiments to study this phenomenon in the laboratory. In fact, researchers have been largely unable to pin down specific variables for predicting how certain words will be shortened, for example whether initial syllables or final syllables would be deleted (e.g. *président ~ prés* vs. *télephòne ~ phóne*), how many syllables would be deleted, whether whole syllables or just vowels would be deleted, or even how morphology affects word truncations. Fisher and McDavid (1973), in a survey of New England speech, and Kypriotaki (1970), in a more widespread study of American English, both noted that omissions of initial syllables occur most often on syllables that bear minimal stress in the word, and most often when the syllable following the deletable syllable bears primary or secondary stress. Zwicky (1972) reported that for word-medial syncope in English, the vowel (or syllable) to be deleted also bears minimal stress, as well as falls into certain segmental contexts (preceding a sonorant consonant). In a comparison between a corpus of television news interviews and a second corpus of three subjects producing both slow and fast versions of test sentences, Dalby (1984) found that in conversational and very fast speech, syllable deletion (or vowel deletion) occurs more often when the syllable is unstressed, has a certain syllable shape (unstressed vowels adjacent to single consonants had much higher deletion rates than did cluster-adjacent vowels), is adjacent to certain manners of articulation (most deletions occurred with syllables in which the vowel was preceded by a sonorant or fricative consonant, or was followed by a stop consonant) and in certain positions in the word (word-medial and post-stress).

In an experiment in which Bell Laboratories employees were asked to abbreviate computer command names, Streeter, Ackroff and Taylor (1983) found that polysyllabic words were most often shortened by truncation of the final syllable(s). In a second series of experiments on word abbreviation behavior, Hodge and Pennington (1973) found that with shorter words, subjects more often omitted word-medial syllables and segments, whereas with longer words, subjects more often omitted word-final syllables and segments (one possible reason lies in the fact that the longer words tended to have suffixes, and the suffixes were the portions that were deleted). Finally, a number of experimental studies in the domain of language processing have shown that the stressed syllable and the word-initial syllable play a key role in lexical access, word recognition, and speech production, and therefore may also play a role in a task such as word reduction (Bradley & Forster, 1987; Grosjean & Gee, 1987 for stressed syllable; Brown & McNeill, 1966; Hawkins & Cutler, 1988; Marslen-Wilson & Welsh, 1978; Nooteboom, 1980 for word-initial syllable).

While these studies have reported somewhat disparate results, taken together, they show that syllable shape, syllable position within the word, primary stress location, and word-length are factors that affect how words are shortened. In addition, cross-linguistic research concerning output responses suggests a strong tendency for adult truncations to result in syllables and feet that form optimal prosodic patterns, either perceptually or productively, regardless of input word length or stress pattern (Itô, 1990 for Japanese; Kilani-Schoch, 1996 for French; Ronneberger-Sibold, 1995 for German; Szpyra, 1995 for English and Polish). This prosodically-based observation mirrors the patterns found in children, discussed above.

Before summarizing the results of the present investigation, however, it is important to mention a few points about stress in general. Every word in English contains one syllable that is more acoustically and perceptually prominent. This syllable is assigned primary stress within the word. If the word has two or more syllables, it may also contain one or more secondarily stressed syllables, with less prominence than the primarily stressed syllable but more than any unstressed syllables (Hammond, 1999). Primary stress is traditionally marked with an acute accent, ´, and secondary stress with a grave accent, `. In English, stress is assigned to heavy syllables, that is, syllables containing either a tense vowel, such as /o/ or /u/, or a coda of one or more consonants (Hammond, 1999; Prince, 1990). Optimally, if there is more than one stress in a word, primary and secondary stress fall on alternating syllables, as in *álmanàc* and *sálamànder*, in which primary stress falls on the first syllable and secondary stress on the third syllable, or as in *càbarét* and *tàpióca*, in which the pattern is reversed, that is, primary stress falls on the third syllable and secondary stress on the first (Hammond, 1999; Hayes, 1995; Hayes, 1984). However, this is not always the case, as in certain words such as *bòmbárd*, *álpìne*, or *bàndána*. Because English contains borrowings from other languages (Bolinger, 1965; Hayes, 1983), it has many varied stress patterns, which makes it an intriguing language for this study.

The goal of this research was to examine word reductions in a large group of subjects, in order to identify predictive patterns of reduction for a variety of polysyllabic word types. These findings will add to the literature on adult word truncations and enhance our existing knowledge of other populations' reductions. Specifically, this project was designed to be a systematic, exploratory study of three factors (stress position, syllable number, and morphology) in order to identify any existent patterns of adult word reduction and any predictable variability between subjects, to determine what similarities to children's reductions they might show, and to create an adult comparison for a second experiment with children. In order to test the validity of the conclusions made in the adult studies reviewed above, we made several predictions regarding reductions in this experiment. The first prediction was that regardless of stress pattern or syllable number of the target word, word reductions should largely conform to a good foot, that is, either a monosyllabic form or a disyllabic form with stress on the first syllable. The second prediction was that the salient features will be preserved – that is, the primary-stressed syllable, the initial syllable and the final syllable will more likely be retained in the response than omitted. The third prediction was that, based on the child data, initial syllables will be omitted more often if they directly precede primary stress. Finally, our prediction regarding morphology is that affixes or segments in the affixes will be omitted more often than segments within the word roots. The present paper will only report on the first two factors (stress position and syllable number), and therefore only the first three predictions.

Experiment

Method

Participants. Fifty-five native English-speaking undergraduates (16 males and 39 females) were recruited from the Indiana University community. All subjects received partial course credit towards an Introductory Psychology class for their participation. The mean age of these participants was 19.09 years (SD = 1.66). Data from 12 subjects were not included in the final analysis due to: being a non-native speaker of English (one subject), having a history of speech disorder (one subject), failing to comply with experimental instructions (seven subjects), excess background noise (two subjects), and recording failure (one subject). The remaining 43 participants were 14 males and 29 females, who had no history of speech or hearing disorders. Participants were assigned to one of two groups. One group received monomorphemic words, and the other group received polymorphemic words (see Stimulus Materials section below). This report will present data from the monomorphemic group condition only. Data from 22 participants (six males and 16 females, mean age of 18.91, SD = 1.23) will be reported in this paper.

Stimulus Materials. The stimuli consisted of 160 polysyllabic monomorphemic words that were used as targets in the monomorphemic condition of the word reduction task and 160 polysyllabic polymorphemic words that were used as targets in the polymorphemic condition.[2] Within each condition, the number of syllables and primary stress location varied systematically. As shown in Table 1, there were eight categories, each with 20 words: disyllabic words with primary stress either on the first syllable (2syl-1pri) or second syllable (2syl-2pri), trisyllabic words with primary stress on the first syllable (3syl-1pri), second syllable (3syl-2pri), or third syllable (3syl-3pri), and quadrisyllabic words with primary stress on the first syllable, (4syl-1pri), second syllable (4syl-2pri), or third syllable (4syl-3pri).[3]

The stimuli were randomly selected from the Hoosier Mental Lexicon (an on-line dictionary of 20,000 entries; Luce & Pisoni, 1998) using the following criteria: first, a lexical frequency rating within one standard deviation of the log mean frequency of each target category (based on values given in Kučera & Francis, 1967); second, a neighborhood density of 2 or lower (neighborhood density was defined as all words that are within one phoneme of the target word by addition, deletion, or substitution), and third, a familiarity rating of at least 6.0 (on a 7-point scale) from undergraduate students (Nusbaum, Pisoni, & Davis, 1984).[4]

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[2] Polymorphemic words contained at least one productive prefix or suffix, as defined by Bybee (1985).
[3] There were only 39 total quadrisyllabic words with primary stress on the fourth syllable, and even fewer that also reached our other criteria, therefore we did not include this pattern in the stimulus set.
[4] Familiarity was set at 6.5 and above for all categories except 3syl-3pri and 4syl-3pri, as these two categories had fewer total words. Familiarity for these words was consequently set at 6.0 in order to collect a sufficient number of words.

Target Category	Number of Syllables	Primary Stress Location
2syl-1pri	2	1st
2syl-2pri	2	2nd
3syl-1pri	3	1st
3syl-2pri	3	2nd
3syl-3pri	3	3rd
4syl-1pri	4	1st
4syl-2pri	4	2nd
4syl-3pri	4	3rd

Table 1. The eight stimulus target categories, the number of syllables found in each category, and the syllable that carries primary stress for each category.

The stimulus set was recorded by a female talker in two blocks, in a sound attenuated chamber (IAC Audiometric Testing Room, Model 402) using a head-mounted Shure (SM98) microphone. The recordings were digitized at 22.05 kHz (16-bit) using a Tucker-Davis Technologies System II sound card and stored in individual files on a PC. The utterances from the second block of two recordings were used, except in a few cases when there was excess noise in the recording (clicks, pops, aspiration picked up by the microphone) in which case stimuli from the first block of recordings were used. All stimulus tokens were judged to be highly intelligible by six phonetically trained listeners. The tokens were segmented into individual digital files and included the entire visible speech signal in both the waveform and the spectral view such that each file started and ended at a zero crossing. The segmented tokens were then leveled to 63 dB (using the Level 16 program developed by Tice & Carrell, 1998).

Procedure

Participants were given both written and verbal instructions, in which they were informed that for each trial they would hear a spoken word over their headphones. Simultaneously with the auditory word presentation, they would see a visual prompt on the screen (“ * ”). For each word they heard, they were asked to first imitate the word in its entirety, and second to generate a “reduced” response. They were provided with examples (e.g., *hìppopótamus ~ híppo*; *biólogy ~ bío*) and reminded that most of the words would not be normally reduced in everyday speech.[5] The participants then had 5.5 seconds to carry out both tasks, that is, imitate the original word in full, and generate the reduced version. A brief practice session preceded the experiment in order to familiarize the participants with the task. Participants were tested individually. The 160 words were presented in three blocks, with two breaks to allow the participants to rest.

The participants’ responses were recorded in the same sound attenuated chamber, using the same head-mounted microphone that was used in recording the test stimuli. Recordings were done in stereo on a Sony DAT deck (DTC-690). The target stimuli were recorded on the right channel while the participants’ responses were recorded on the left channel. Both the target stimuli and responses were later streamed at 48kHz (16-bit) in stereo into individual digital files for storage and analysis on a PC using a Roland UA-40 external Analog to Digital converter and Syntrillium’s CoolEdit Pro LE.

[5] While most words in the stimulus set did not have a common English reduction, 6.9% of the words did, such as *mèmorándum, ìnfluénza,* and *hélicòpter.* These were included because they had been in the original random selection of words from the on-line dictionary, and as they constituted only a minimal portion of the word list, we did not think they would affect participants’ performance. If anything, they would act to remind the participants about the type of reduction we were looking for.

The repetition and reduction responses were then transcribed and coded by the two experimenters and a third research assistant, all trained in broad phonetic transcription, using a coding scheme based on the International Phonetic Alphabet (IPA). For reliability purposes, 10% of each subject's transcriptions were verified by one of the other transcribers, and tokens that two transcribers disagreed upon were examined by the third person. Any transcriptions that remained unresolved were not included in the analysis. Interjudge agreement for transcriptions was 95.2% for repetition responses and 92.9% for reduction responses. Reduction responses were then coded for four features: the prosodic output pattern (a monosyllabic foot, a disyllabic trochaic foot, or some other pattern), whether the original stressed syllable was preserved (either as the stressed syllable or as a reduced syllable), whether either the initial or final syllable of the word was preserved, and which syllables were omitted in creating the reduced form. Interjudge agreement for reduction response coding was 96.6%. A small portion of participants' responses (2.2%) was omitted from coding due to non-responses, misperception of the stimulus, stress shift in the repetition of the stimulus, and any phonologically unrelated reductions of the target (e.g., *cònstellátion ~ stárs*).

Results

Examples of several target stimuli and subject responses are given in Table 2. The first column represents the syllable number and primary stress location of each target word group of the stimuli, and the second column shows a corresponding example word. The third column shows a typical example of subjects' repetition responses for each stimulus word, transcribed using the IPA. The fourth column shows a typical reduction response for each repetition, also transcribed in IPA. For example, the second row, 2syl-1pri, shows a typical response for the target word *máple*, which has two syllables and primary stress on the initial syllable: a repetition, [meɪ́pl̩], followed by a reduction, [meɪ́p].

Syllable number and stress pattern	Example of stimulus word	Example of repetition response	Example of reduction response
2syl-1pri	máple	méɪpl̩	méɪp
2syl-2pri	gazélle	gəzɛ́l	zɛ́l
3syl-1pri	Ámazòn	ǽməzɔ̀n	zɔ́n
3syl-2pri	màrtíni	mɑ̀rtíni	tíni
3syl-3pri	tàngeríne	tæ̀ndʒərín	tǽndʒ
4syl-1pri	sálamànder	sǽləmæ̀ndɚ	mǽndɚ
4syl-2pri	aquárium	əkwɛ́rim̩	kwɛ́rim̩
4syl-3pri	tàpióca	tæ̀pióʊka	tǽpi

Table 2. Examples of stimulus words, repetition responses (in IPA), and reduction responses (in IPA) for each target category.

The results of reduction response coding for the 22 subjects are summarized in Figures 1 through 5. Figure 1 shows the prosodic output patterns, coded as a monosyllabic foot, such as [méɪp] for *máple*, a disyllabic trochaic (strong-weak) foot, such as [mǽndɚ] for *sálamànder*, or *Other* (this category comprised patterns of either a disyllabic reduction with second syllable stress, e.g., [əkwɛ́r] for *aquárium* or any type of trisyllabic reduction, e.g., [kwɛ́rim̩] for *aquárium* or [pióʊkə] for *tàpióca*). This graph displays results relevant to our first prediction, which was that regardless of stress pattern or syllable number of the target word, word reductions should largely conform to a well-formed prosodic foot, that is, either a monosyllabic form or a disyllabic form with stress on the first syllable.

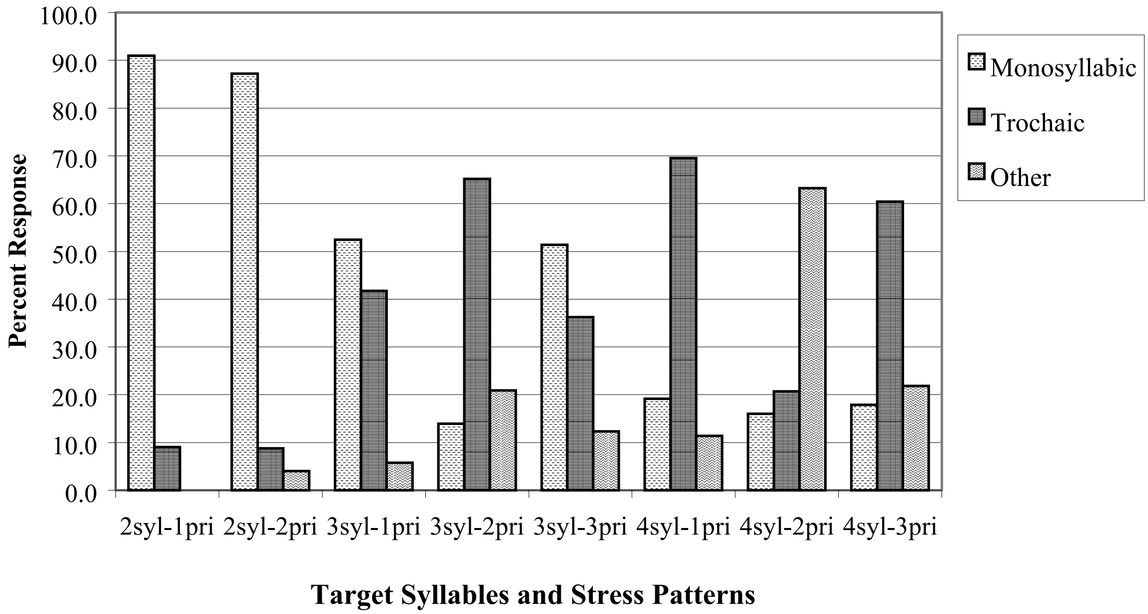

Figure 1. Percent of reduction responses that contained a monosyllabic foot, a disyllabic trochaic foot, or other output pattern, for each target category.

Subjects reduced words significantly more often to a monosyllabic foot than to a disyllabic foot or an *Other* form ($\chi^2 = 8.49$, $df = 1$, $p < .01$; $\chi^2 = 377.91$, $df = 1$, $p < .001$, respectively), and significantly more often to a disyllabic foot than to an *Other* form ($\chi^2 = 278.32$, $df = 1$, $p < .001$). Out of eight original target categories, seven categories were reduced by subjects most often to either a monosyllabic foot or a disyllabic foot. Four categories were reduced by subjects most often to a monosyllabic foot. First, the 2syl-1pri category was reduced to a monosyllabic foot more often (in 90.9% of responses) than either a disyllabic foot (9.1%) or *Other* form (0%). The difference between monosyllabic foot responses and disyllabic foot responses was statistically significant ($\chi^2 = 289.89$, $df = 1$, $p < .001$). Second, the 2syl-2pri category was also reduced to a monosyllabic foot more often (in 87.2% of responses) than either a disyllabic foot (8.7%) or *Other* form (4.0%). These differences were also statistically significant ($\chi^2 = 275.36$, $df = 1$, $p < .001$ and $\chi^2 = 324.96$, $df = 1$, $p < .001$, respectively). These two results were expected given the nature of the experimental design: the targets were originally disyllabic (e.g., *máple* and *gazélle*) and a reduction response typically yielded a monosyllable (e.g., [méɪp] or [zɛ́l]). Third, the 3syl-1pri target category, although showing somewhat more variation in reduction responses, was also reduced significantly more often to a monosyllabic foot, as in *óbstacle* ~ [ɔ́b] (52.5%) than to either a disyllabic foot or *Other* pattern ($\chi^2 = 5.62$, $df = 1$, $p < .05$ and $\chi^2 = 163.84$, $df = 1$, $p < .001$, respectively). Likewise, the 3syl-3pri target category was reduced significantly more often to a monosyllabic foot, as in *bàssinét* ~ [nɛ́t] (51.4%) than to either a disyllabic foot (36.3%) or *Other* pattern (12.4%. $\chi^2 = 10.14$, $df = 1$, $p < .01$ and $\chi^2 = 97.08$, $df = 1$, $p < .001$, respectively).

Three target categories were reduced more often to a disyllabic foot than to either a monosyllabic foot or to an *Other* pattern. The 3syl-2pri target category resulted in a disyllabic foot reduction, such as *mànháttan* ~ [hǽʔn̩], in 65.2% of responses, but in a monosyllabic foot, such as *mànháttan* ~ [hǽt], in 13.9% of responses. This difference was statistically significant (χ^2 = 142.35, *df* = 1, *p* < .001). In addition, the 3syl-2pri category resulted in a disyllabic foot significantly more often than an *Other* pattern, which occurred in 20.9% of responses (χ^2 = 98.86, *df* = 1, *p* < .001). This reduction response pattern was due to a strong tendency for the initial, pre-stress syllable to be deleted (see Figure 5), as we predicted. The 4syl-1pri and 4syl-3pri target categories demonstrated similar results for output reductions, with a disyllabic foot reduction in 69.5% and 60.4% of responses, respectively (*córonàry* ~ [kɔ́roʊ], and *èpidémic* ~ [dɛ́mək]). Both of these patterns occurred more often than a monosyllabic pattern (χ^2 = 122.95, *df* = 1, *p* < .001 for 4syl-1pri and χ^2 = 99.37, *df* = 1, *p* < .001 for 4syl-3pri), or an *Other* pattern (χ^2 = 180.52, *df* = 1, *p* < .001 for 4syl-1pri and χ^2 = 76.70, *df* = 1, *p* < .001 4syl-3pri). In looking at reductions of these seven target categories, longer target words tended to be reduced more often to a disyllabic form.

Only one category, the 4syl-2pri category, was notably reduced most often to the *Other* category, in 63.2% of responses, whereas it was reduced to a monosyllabic foot in 16.0% of responses and to a disyllabic foot in 20.7% of responses. The differences between an *Other* response and a monosyllabic foot response, and an *Other* response and a disyllabic foot response, were significant (χ^2 = 123.36, *df* = 1, *p* < .001 and χ^2 = 93.77, *df* = 1, *p* < .001, respectively). Reductions in this category typically were in the form of either a disyllabic form with stress on the second syllable (as in *aquárium* ~ [əkwɛ́r]) or a trisyllabic form with stress on the initial syllable (as in *aquárium* ~ [kwɛ́rim̩]). The reduction responses were consistent with our first prediction, and suggest that adults reduce words to a prosodically optimal form (either a monosyllabic or disyllabic foot). The overall pattern of responses was consistent with the prior research on children's and adults' outputs, summarized above.

Our second prediction involved the preservation of salient syllables (stressed, initial and final). First, we predicted that subjects' patterns of reduction responses would retain the stressed syllable of the target words more often than omit it. Actual word reduction responses yielded three patterns: responses that included the primary-stressed syllable from each target category as the primary-stressed syllable (e.g., *màrtíni* ~ [tíni]), responses that included the primary-stressed syllable in a reduced capacity (resulting from a stress shift, e.g., *màrtíni* ~ [márɾi]), and responses in which the primary-stressed syllable was omitted (e.g., *màrtíni* ~ [már]). Figure 2 shows the mean percentage of reduction responses containing these three patterns. Of the reduction responses that preserved the primary-stressed syllable, more responses retained the syllable in its original stressed form (34.2% to 85.5% across the eight target categories) than retained the syllable in a reduced form (0% to 14.2%). This difference was statistically significant (χ^2 = 1720.17, *df* = 1, *p* < .001). However, there were also significantly more responses that omitted the original stressed syllable (ranging from 12.8% to 62.9%) than retained it in a reduced form (χ^2 = 346.42, *df* = 1, *p* < .001). The small percentage of primary-stressed syllables resulting in a reduced syllable comes from the relatively small percentage of stress shifts. Across the three word length types (disyllabic, trisyllabic, quadrisyllabic), target categories with first-syllable primary stress had the fewest stress shifts (0% to 1.6%), and target categories with second-syllable primary stress had the most stress shifts (4.7% to 14.2%).

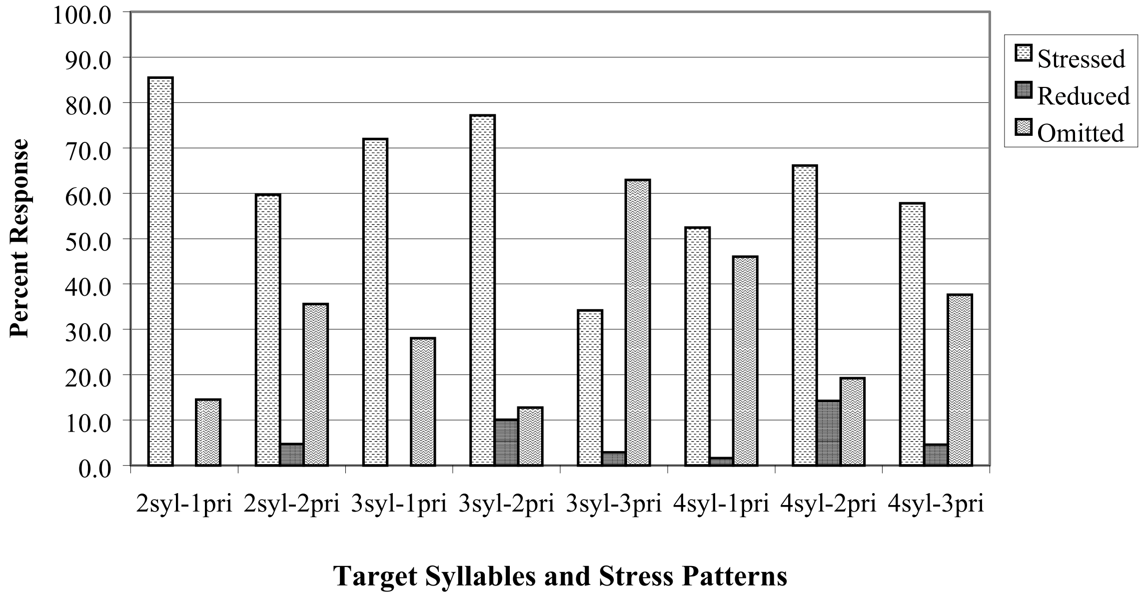

Figure 2. Percent of word reduction responses in which the stressed syllable was preserved as the stressed syllable, preserved but as a reduced (unstressed) syllable, or omitted altogether, for each target category.

Four patterns were noteworthy regarding stressed syllables that were preserved as the stressed syllable. First, there was a difference between the reduction responses for the two disyllabic targets. For the 2syl-1pri category, the stressed syllable was preserved as the stressed syllable in 85.5% of responses, as reduced in 0% of responses, and omitted in 14.5% of responses. The difference between preservation (as stressed) and omission of the stressed syllable was statistically significant (χ^2 = 213.18, df = 1, p < .001). In contrast, for 2syl-2pri, the stressed syllable was preserved as the stressed syllable in only 59.7% of responses, as a reduced syllable in 4.7% of responses, and omitted in 35.6% of responses. Goodness of fit chi-square tests showed each of the three to be statistically different from the others. That is, the difference between preservation of the stressed syllable as stressed and the stressed syllable in a reduced form (χ^2 = 199.84, df = 1, p < .001), the difference between preservation of the stressed syllable as stressed and omission of the stressed syllable (χ^2 = 25.06, df = 1, p < .001), and the difference between preservation of the stressed syllable as reduced and omission of the stressed syllable (χ^2 = 102.25, df = 1, p < .001) were all significantly different. The high rate of preservation of the stressed syllable as the stressed syllable, alongside a rate of 0% stressed syllable as reduced in 2syl-1pri, reflects the bias for content words to have initial syllable stress in the language. In addition, the preservation of the stressed syllable as reduced in 2syl-2pri was largely due to a stress shift, yielding a stressed initial syllable, while preserving the original stressed syllable.

A second finding was that the stressed syllable was preserved in its stressed form in 71.9% of word reductions for the category 3syl-1pri. This pattern occurred significantly more often than omission of the syllable, at 28.1% (χ^2 = 82.12, df = 1, p < .001). Again, as in 2syl-1pri, there were no occurrences of the stressed syllable as a reduced syllable. This result also supports the notion of salience of a stressed initial syllable.

Third, the stressed syllable was preserved as the stressed syllable least often of all target categories for 3syl-3pri, at 34.2% (an example of a more frequent reduction response for this target category was [sílo͡ʊ] for *sìlhouétte*). This pattern occurred significantly less often than omission of the stressed syllable, which occurred in 62.9% of responses ($\chi^2 = 36.48$, $df = 1$, $p < .001$). This result was not surprising, in light of the tendency for initial syllables of this category to be preserved at a high rate (see Figure 3). In fact, the finding suggests that although stress and final syllable position are both salient positions, at a certain point, the initial syllable is more likely to be preserved, regardless of stress position. This finding will be revisited in the following sections.

The fourth noteworthy response pattern occurred with the 4syl-1pri target category. Contrary to expectations, the primary stressed syllable was not consistently maintained in reductions. The stressed syllable was preserved as the stressed syllable in 52.4% of reduction responses, and it was omitted in 46.0% of responses. This difference was not statistically significant. The pattern can be interpreted as the omission of one of the two prosodic feet and the preservation of the other, as in *mátrimòny* ~ [mǽtri] or [mó͡ʊni]. This random pattern of foot omissions becomes even more evident in Figure 3. Overall, the consistent finding that subjects faithfully maintained the primary-stressed syllable as the stressed syllable in their reduction responses supports earlier findings reported by Cutler and Carter (1987), Echols (1993) and Echols and Newport (1992) on the salience of stressed syllables. However, other factors such as location of primary stress in the word also affects this salience.

With regard to initial syllables, as with stressed syllables, our prediction was that initial syllables would be preserved more often than they would be omitted. Figure 3 shows the mean percentage of responses that preserved the initial syllable, as in *gazélle* ~ [gǽz], and that omitted the initial syllable, as in *gazélle* ~ [zɛ́l], for all target categories.

Reduction responses to four of the eight target categories preserved the initial syllable significantly more often than omitted it. The initial syllable was preserved significantly more often for 2syl-1pri ($\chi^2 = 213.18$, $df = 1$, $p < .001$), 3syl-1pri ($\chi^2 = 82.12$, $df = 1$, $p < .001$), 3syl-3pri ($\chi^2 = 46.67$, $df = 1$, $p < .001$) and 4syl-2pri ($\chi^2 = 16.26$, $df = 1$, $p < .001$). The results for 2syl-1pri and 3syl-1pri categories suggest that primary stress, especially when falling on the initial syllable, is a good predictor for preservation of that initial syllable in word reductions of di- and trisyllabic words. The reduction response pattern for the target category 3syl-3pri (66.5% preservation rate) was unexpected, given that the target category has final syllable stress. This result suggests a possible preference for the word-initial syllable over the word-final syllable, despite the fact that the final syllable carries main stress. However, the initial syllable has secondary stress in many words from this category (e.g., *bàssinét*), which may provide an explanation: an initial syllable with secondary stress may be more salient than an unstressed initial syllable typical of, for example, 3syl-2pri targets. The result for the 4syl-2pri category was due to disyllabic iambic reduction patterns such as *aquárium* ~ [əkwɛ́r] (see Figure 1).

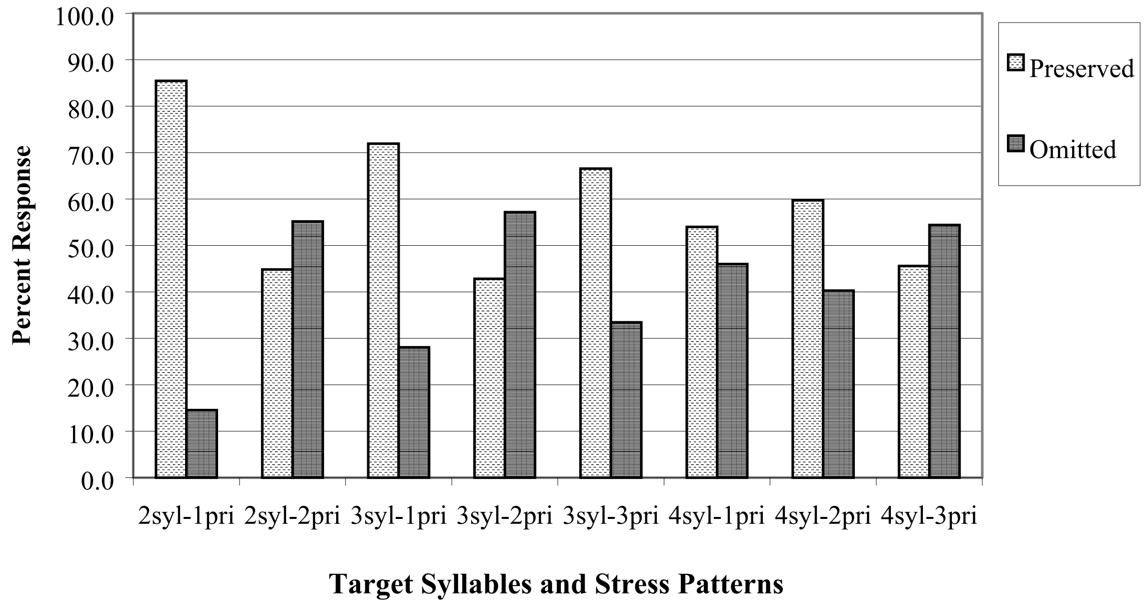

Figure 3. Percent of word reduction responses in which the initial syllable was preserved or omitted, for each target category.

Our prediction was not borne out for four target categories: 2syl-2pri, 3syl-2pri, 4syl-1pri, and 4syl-3pri. For the categories 2syl-2pri and 3syl-2pri, the initial syllable was actually omitted significantly more often than it was preserved ($\chi^2 = 4.33$, $df = 1$, $p < .05$ and $\chi^2 = 9.25$, $df = 1$, $p < .01$, respectively). Both target categories carry primary stress on the second syllable, and the initial syllable was the most often omitted syllable, leaving either the final monosyllabic foot (2syl-2pri) or the final disyllabic foot (3syl-2pri). These patterns were identical to typical omissions of the weak initial syllable found in other populations. The categories 4syl-1pri and 4syl-3pri showed no statistical difference between preservation and omission of the initial syllable (54.0% preservation for 4syl-1pri and 45.6% for 4syl-3pri). These results suggest once again that for 4syl-1pri, as well as for 4syl-3pri, subjects randomly preserved either the first or second foot and omitted the other, when reducing these categories. In summary, initial syllables were preserved more often than they were omitted for four of the eight target categories.

Figure 4 shows the mean response percentages for final syllable preservation and omission in word reduction. With regard to final syllables, the predicted outcome was that final syllables would also be preserved more often than omitted. However, there was only one category for which the predicted outcome was borne out, the 2syl-2pri category. The final (stressed) syllable was retained in 64.4% of responses, significantly more often than it was omitted, in 35.6% of responses ($\chi^2 = 34.29$, $df = 1$, $p < .001$).

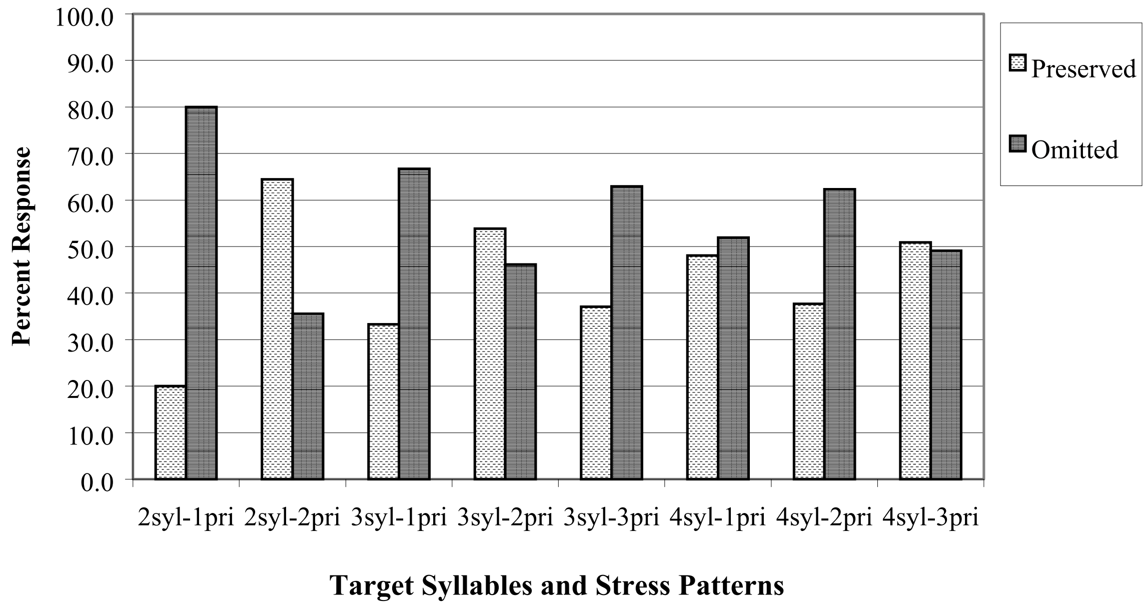

Figure 4. Percent of word reduction responses in which the final syllable was preserved or omitted, for each target category.

For five target categories, the final syllable was omitted significantly more often than it was preserved: 2syl-1pri, 3syl-1pri, 3syl-3pri, 4syl-1pri and 4syl-2pri. The result obtained for the 2syl-1pri category was not surprising, since the majority of reduction responses yielded monosyllabic forms and included the initial syllable (see Figures 1 and 3). However, it was unexpected once again that reduction responses from the 3syl-3pri category patterned as they did. There was no statistically significant difference between preservation and omission of the final syllable for two of the target categories, 3syl-2pri and 4syl-3pri. Taken together, the results for final syllable preservation suggest that the final syllable is not as salient a feature as the stressed or initial syllables are, except in the case of 2syl-2pri (where fewer strategies exist to reduce words).

A final interesting note is the distribution of initial and final syllable preservation responses for 2syl-1pri and 2syl-2pri. One might predict that with only two syllables to choose from in the target, the distribution of initial and final syllable preservation rates would be complementary. However, while the pattern of preservation was in the opposite direction (2syl-1pri had a higher percent of preservations of the initial syllable and 2syl-2pri had a higher percent of preservations of the final syllable), the rates of preservation were noticeably different (85.5% initial and 20.0% final for 2syl-1pri vs. 44.8% initial and 64.4% final for 2syl-2pri). A similar response distribution was found for the 3syl-1pri and 3syl-2pri targets (71.9% initial and 33.3% final for 3syl-1pri vs. 42.8% initial and 53.9% final for 3syl-2pri). These patterns once again reflect the tendency for English words to begin with a stressed syllable, and support the hypothesis that stressed, initial syllables are salient.

Figure 5 gives the mean response percentages of syllable omissions across the eight target categories. That is, for each reduction response, we counted which syllable or syllables were omitted in the response: either the first or second syllable for the disyllabic targets, any of the first, second, or third syllables for the trisyllabic targets, and any of the first through fourth syllables for the quadrisyllabic targets.

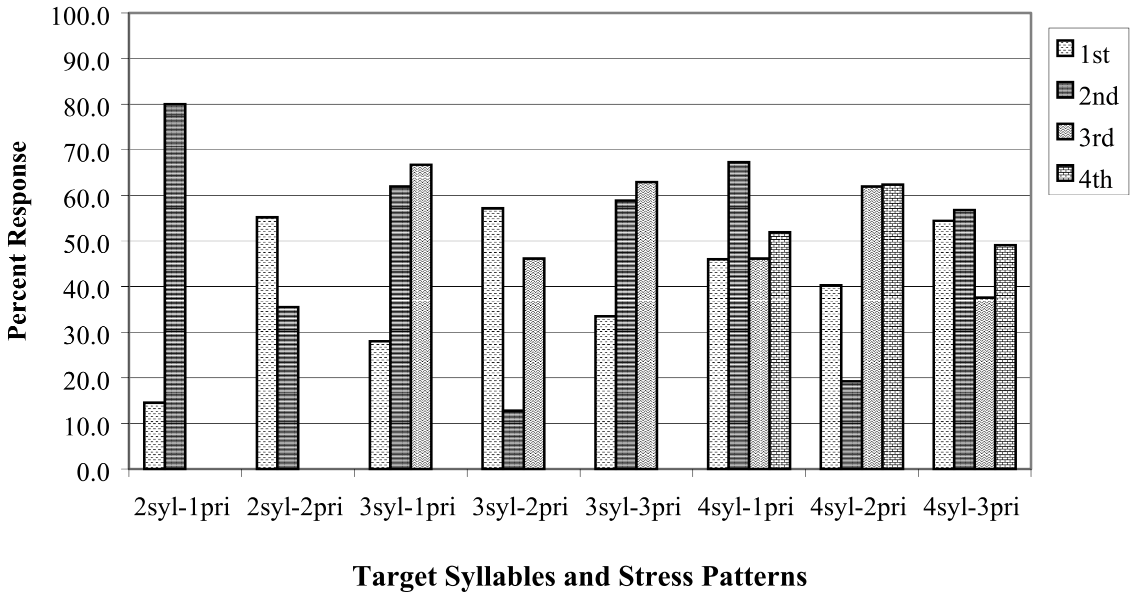

Figure 5. Percent of word reduction responses containing omissions of the first, second, third, or fourth syllable, for each target category.

The data shown here can be used to address our third prediction, which was that initial syllables that directly precede primary stress would be omitted more often than initial syllables containing primary stress or initial syllables that do not directly precede primary stress (stemming from the children's production literature). The prediction was supported for the first two target categories 2syl-2pri and 3syl-2pri, yielding responses that were similar to children's productions (e.g., *gazélle* ~ [zɛ́l] and *màrtíni* ~ [tíni]). For disyllabic words, the pretonic initial syllable in 2syl-2pri was omitted significantly more often than the stressed initial syllable in 2syl-1pri ($\chi^2 = 100.77$, $df = 1$, $p < .001$). For trisyllabic words, the pretonic initial syllable in 3syl-2pri was omitted significantly more often than the initial syllable in 3syl-1pri and 3syl-3pri ($\chi^2 = 41.0$, $df = 1$, $p < .001$ and $\chi^2 = 29.11$, $df = 1$, $p < .001$, respectively). The prediction was not supported for 4syl-2pri targets, that is, there was no difference between percentage of omissions of the initial syllable from 4syl-2pri and 4syl-1pri, and the pretonic initial syllable in 4syl-2pri was actually omitted significantly less often than the initial syllable in 4syl-3pri ($\chi^2 = 8.78$, $df = 1$, $p < .01$).

There were several other noteworthy observations regarding the analysis of syllable omissions. First, although the expected complementary omission rate difference existed between 2syl-1pri (final unstressed syllable omitted more often) and 2syl-2pri (initial unstressed syllable omitted more often), this complementary pattern was uneven, with more unstressed syllable omissions occurring for 2syl-2pri. This was most likely due to a difference in initial and final syllable preservation that was discussed in previous sections. Second, the similar rates of omission of the second and third syllables from the 3syl-1pri target category (61.9% and 66.7%, respectively) suggest that when the output was of a disyllabic form, either syllable was employed as the second syllable. Third, the high rate of second syllable omissions from 4syl-1pri was the result of a large number of trisyllabic reductions such as *áppetìzer* ~ [ǽptɑ̀ɪzɚ] or *cémetèry* ~ [sɛ́mtɛ̀ri], in which the unstressed second syllable, often a schwa, was the only omitted syllable. Fourth, the unusual pattern of omission rates for 4syl-2pri was again due to reductions such as *aquárium* ~ [əkwɛ́r], as discussed in previous sections.

General Discussion

The data summarized in Tables 3 through 5 provide an overview of the major findings reported above. Table 3 gives the generalizations for word reduction responses for disyllabic target categories (e.g., *máple* and *gazélle*), Table 4 gives generalizations for word reduction responses for trisyllabic target categories (e.g., *óbstacle*, *bàndána, nèctaríne*), and Table 5 gives generalizations for quadrisyllabic target categories (e.g., *mátrimòny*, *aquárium*, and *tàpióca*). Each column corresponds to the specific patterns we were interested in: the output foot pattern (whether monosyllabic, i.e., "S", disyllabic and trochaic, i.e., "Sw", or *Other*), the proportion of reduced responses that preserved the stressed syllable as the stressed syllable more often than preserving it as reduced or omitting it, the proportion of reduced responses in which the initial syllable and final syllable were preserved more often than omitted, and the syllable or syllables that were omitted most often in word reductions. For each table, note that for the column labeled "syllable(s) omitted most often", shaded cells denote no possible deletable syllable (e.g., for 2syl-1pri and 2syl-2pri, there were no third or fourth syllables to be deleted).

	Most common output prosodic pattern			Stressed syll. preserved with stress more often than reduced or omitted	Syllable preserved more often than omitted		Syllable(s) omitted most often			
	S	Sw	Other		Initial	Final	1	2	3	4
2syl-1pri	✓			✓	✓			✓		
2syl-2pri	✓			✓		✓	✓			

Table 3. Summary of results for reduction responses for 2syl-1pri and 2syl-2pri categories.

	Most common output prosodic pattern			Stressed syll. preserved with stress more often than reduced or omitted	Syllable preserved more often than omitted		Syllable(s) omitted most often			
	S	Sw	Other		Initial	Final	1	2	3	4
3syl-1pri	✓			✓	✓			✓	✓	
3syl-2pri		✓		✓			✓			
3syl-3pri	✓				✓			✓	✓	

Table 4. Summary of results for reduction responses for 3syl-1pri and 3syl-2pri, and 3syl-3pri categories.

	Most common output prosodic pattern			Stressed syll. preserved with stress more often than reduced or omitted	Syllable preserved more often than omitted		Syllable(s) omitted most often			
	S	Sw	Other		Initial	Final	1	2	3	4
4syl-1pri		✓						✓		
4syl-2pri			✓	✓	✓				✓	✓
4syl-3pri		✓		✓			✓	✓		✓

Table 5. Summary of results for reduction responses for 4syl-1pri and 4syl-2pri, and 4syl-3pri categories.

The initial analysis of the word reduction data collected in this task suggests that the relationship between word length, primary stress location, and syllable omissions is complex. We found a strong tendency for adult speakers to reduce words into a well-formed prosodic foot (monosyllabic or disyllabic) that still contains the original primary-stressed syllable. However, this was not true of all eight target syllable and stress patterns. For example, we found that word reductions of the 4syl-2pri category showed a trend toward some other output pattern (as in [əkwɛ́r] or [kwɛ́rim̩]).

Three general conclusions can be drawn from the analysis of preserved salient syllables in reduction responses. First, the stressed syllable was overwhelmingly preserved as the stressed syllable in the reduction responses. Second, the initial syllable was preserved more often than omitted under certain conditions, including when the initial syllable contained main stress. Third, only when the final syllable of a disyllabic word contained main stress, was it preserved more often than omitted.

The response patterns for the preservation of salient syllables however, were not consistent across all categories. Specifically, 3syl-3pri words tended to be reduced without the primarily-stressed syllable from the target and 4syl-1pri and 4syl-3pri showed a trend to be reduced arbitrarily to either the first or second foot. This arbitrary reduction is also suggested by the rates of preservation of the initial and final syllables in these same words. Although the primary-stressed syllables were frequently preserved in the reductions, reductions of these categories yielded equivalent omission rates between the primary-stressed syllable and another syllable in the word. Each of these categories carry secondary stress: in 3syl-3pri and 4syl-3pri it falls on the initial syllable, and in 4syl-1pri it falls on the third syllable. The weight or salience, which may exist in the secondary-stressed syllable, may very well be playing a role in responses. Thus, a post-hoc analysis including secondary stress versus zero stress may be warranted.

Overall, the different patterns of syllable omissions across the various target syllable and stress patterns complement the data on syllable preservation and also suggest that there are interactions between initial and final syllables, and possibly between primary- and secondary-stressed syllables, in the input categories that leads to a complicated set of outputs. The analysis of syllable omissions suggests that for di- and trisyllabic words, the same output patterns occur for children and for adults. Namely, initial syllables are omitted more often when they directly precede primary stress in the word. However, this is not the case for four-syllable words, and since omissions from four-syllable words are not well-documented for children, it is unclear how adults' responses compare to children's for this group of words.

Taken together, it appears that reduction responses for four target categories matched our earlier predictions. These are 2syl-1pri (due to the salience of the initial stressed syllable), 2syl-2pri (due to the salience of the final stressed syllable and the omission of the pre-tonic initial syllable), 3syl-1pri (due to the salience of the initial stressed syllable), and 3syl-2pri (due to the omission of the pre-tonic initial syllable). However, reduction responses for the remaining four target categories did not match our predictions. These are 3syl-3pri (perhaps due to secondary stress or the relative infrequency of this pattern in English), 4syl-1pri and 4syl-3pri (perhaps due to secondary stress), and 4syl-2pri (due to the salience of the initial syllable, or possibly the less than optimal presence of two adjacent unstressed syllables; Hammond, 1999). Further analysis is necessary to examine these predicted and unpredicted patterns, in light of secondary stress facts and the frequency of stress patterns in English.

Additionally, even within a given syllable and stress pattern that tends to demonstrate reductions to well-formed feet, data were subject to variation across and within subjects. Some subjects had systematic "strategies" in their responses, such as always preserving the initial syllable, or adhering to a well-formed disyllabic foot more often than any other pattern, however other subjects randomly reduced words with no apparent strategies. A post-hoc analysis is planned to examine this subject variation and variability.

Finally, some reductions were obviously based on orthography (e.g., *anátomy* ~ [tɔ́m] and *tròmbóne* ~ [tíbòʊn], i.e., *t-bone*). Clearly, with literate adults, orthography may affect spoken word processing, especially in tasks that ask subjects to explicitly and consciously manipulate real words in somewhat unnatural ways (Jakimik, Cole, & Rudnicky, 1985; Jared, McRae & Seidenberg, 1990; Kreidler, 1979). In order to keep orthographic effects at a minimum, we specifically presented the words in an auditory-only modality. Consequently, the number of obvious orthographically-based responses was small.

Future Directions

As this study is ongoing, we will continue to analyze the coding data from the monomorphemic condition group to look for secondary stress effects and individual differences, across both subjects and items. In addition, we plan to examine the response times obtained in this task. Specifically, we will measure the interval between offset of the target stimulus and onset of the repetition response as well as the interval between offset of the repetition response and onset of the reduction response, in order to assess any effects of syllable number and stress patterns (or frequency of certain prosodic patterns) on response time. It is possible that a less frequent stress pattern such as 3syl-3pri might yield longer response times to construct a word reduction response than a more frequent stress pattern, such as 3syl-1pri. Second, as mentioned in the Methods section, we have collected data from a polymorphemic condition group as well. We plan to carry out identical analyses to those reported in this paper on word reduction responses from that subject group. Once those data are analyzed, we will compare data from the two conditions in order to study effects of morphology on word reductions (Hamans, 1996; Hodge & Pennington, 1973).

Third, we plan to carry out a version of this experiment using the same stimuli with children who are in their third year, approximately between the ages of 26 months and 36 months. Few child studies have examined omissions systematically across syllable number and primary stress location, and no studies have described the syllable omissions from four-syllable words by children. Therefore, the adult responses will provide a comparison for children's reduction responses. This was one of the reasons for using auditory stimuli: we needed a presentation mode that was amenable to both literate adults as well as pre-literate children. Finally, in running a pilot version of this study, a volunteer subject who is a speaker of Singaporean English found it difficult to reduce the target words or to perform the task at all. On further examination, we found that while American English is considered to be a stress-timed language (every stressed syllable in an utterance is an even amount of time away from the next), Singaporean

English is a syllable-timed language, in which every syllable nucleus is isochronous (Deterding, 2001; Lehiste, 1971; Platt & Weber, 1980). Running this experiment on speakers of Singaporean English will provide an interesting comparison to our American English population.

In summary, our initial findings using a word reduction task provide evidence that word length and primary stress position do affect word reduction strategies of adults in certain systematic ways. In addition, the pattern of responses is similar to word reductions observed in young children and several clinical populations. However, these findings also support the conclusions of previous researchers that the phenomenon of word reduction is a complex one. Further analyses of reduction responses of the full subject set may yield even stronger predictors for output patterns based on prosodic or morphological patterns of the input. The complete study will hopefully provide a controlled, experimental addition to the current linguistic and psycholinguistic literature on the nature of word reductions in adults, children, and clinical populations.

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