*Prosodic Effects on Word Reduction**

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Key words

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Abstract

It is widely known that English-speaking children reduce words by omitting syllables in certain predictable patterns (e.g., *banána ~ nána)*. One way to better understand the nature of phonological reductions in children is to examine adults' word reduction behavior. This study explored whether adults produce predictable output patterns when reducing words. Undergraduate participants heard a list of polysyllabic words varying systematically across syllable number and primary stress location and were asked to generate a "reduced" form, similar to common English reductions (e.g., *rhinóceros ~ rhíno*). Regardless of stress and syllable number, participants reduced the stimulus words significantly more often to left-headed disyllabic or monosyllabic feet, retaining stressed syllables and omitting unstressed syllables. The general bias found was similar to that which children exhibit in natural speech, namely, to maintain well-formed prosodic patterns and preserve salient syllables. On the other hand, a tendency to preserve word-initial instead of word-final syllables was also found, suggesting subtle differences in language processing between children and adults. The current study contributes to the psycholinguistic literature on adults' syllable omissions in abbreviations and fast-speech registers by examining the processing strategies that adults may use when reducing words.

1 Introduction

Word reductions are a common phenomenon in the English language. Lexicographers have long been fascinated by the abundance of oral and written reductions found in American English (Cannon, 1989; Gonzalez, 1992). However, the process of English word reduction and the properties of reduced forms have largely been ignored in the linguistic literature (Szpyra, 1995). In normal adult speech, word reductions are often the result of a tendency to abbreviate longer or commonly used words, such as *rhíno* for *rhinóceros* or *Bécca* for *Rebécca*, and certain speech registers, for example, *cáuse* for *becáuse* in

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casual or fast speech. Word reductions are also pervasive in the productions of very young, preliterate children, and are the naturally occurring outcomes of attempts to produce polysyllabic utterances, such as *ráffe* for *giráffe*, *nána* for *banána*, or *éfant* for *élephant* (Gerken, 1994a; Smith, 1973). Although some attempts have been made to categorize and study adult truncations, the bulk of word reduction research in English has been conducted on the phenomenon as it pertains to young children, in an effort to account for the patterns found throughout various stages of children's language development. Following a review of the literature on single word reductions of children and adults, we will describe an experiment that was designed to examine adults' truncations of multisyllabic targets with various stress patterns, in order to provide further examination of word reductions in adults under controlled conditions, as well as to provide a point of comparison in adults for the phenomenon seen in children.

1.1 *Word reduction by children*

Research on English-speaking children's word truncations indicates that between the ages of 1;6 and 3;0 children begin to produce polysyllabic words, usually of two or three syllables in length, and occasionally, four or five. In their attempts to produce these polysyllabic words, two-year-olds often shorten them by omitting syllables in fairly predictable patterns. It is well attested that children omit unstressed syllables from their words more often than they omit stressed syllables. Among weakly stressed syllables, children are more likely to omit those from word-initial position than those from word-internal or word-final positions (Allen & Hawkins, 1980; Carter, 2000; Demuth, 1995; Fee, 1996; Gerken, 1994a, b, 1996; Klein, 1981), and children are more likely to omit weakly stressed syllables from word-medial position than from word-final position (Echols & Newport, 1992; Fikkert, 1994; Kehoe, 1999/2000; Kehoe & Stoel-Gammon, 1997a, b). The output pattern of two-year-olds' single word truncations is most often a form with primary stress on the initial syllable and an optional weak syllable following. Often this optional weak syllable is the final syllable of the target form. In other words, the output form generally corresponds to a prosodic foot, that is, either a trochee (a disyllabic word with stress on the initial, left-most syllable) as in [nǽnə] (*banána*) or [éfənt] (*élephant*), or a monosyllabic, heavy foot as in [ræf] (*giráffe*).

While a variety of accounts have been put forth to explain these syllable omissions and consequent output patterns, we will briefly summarize four. The first account of English children's word reductions posits a Minimal Word constraint on their early language production (Demuth, 1995, 1996; Fee, 1996; Pater & Paradis, 1996). Proponents of this account suggest that children's productions pass through a stage in which their words are minimally and maximally a stress-sensitive disyllabic foot. This account was formalized by Demuth (1995) and Pater and Paradis (1996) using Optimality Theory (Prince & Smolensky, 1993), in which well-formedness constraints act upon output representations of a word to yield the most optimal candidate, which is then produced. Words with weakly stressed, word-initial unfooted syllables, as in *ba-nána*, are therefore often reduced to a Minimal Word by omission of the initial syllable (Demuth, 1996; Gerken, 1996; Salidis & Johnson, 1997; Stemberger & Bernhardt, 1997).

The second account is referred to as the metrical template account (Allen &

Hawkins, 1980; Gerken, 1994a, b). The basis for this account 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. In addition, English is considered to exhibit a trochaic (Strong-weak) metrical foot structure (Hayes, 1982; Liberman & Prince, 1977). The metrical template account builds on these two findings to suggest that the input that children perceive most often contains a trochaic stress pattern, and therefore children's outputs, regardless of the input, are restricted to this same form, or at least a strong syllable followed by an optional weak syllable: S-(w) (Gerken, 1994a). Evidence for the trochaic template has been proposed in the infant literature as well, most notably by Jusczyk, Cutler, and Redanz (1993), in which it was found that infants as young as nine months of age listened significantly longer to English words with Sw stress patterns than to words with wS stress patterns. Under the trochaic template account, any syllable that does not conform to the S-(w) foot template is thus omitted. For example, the initial unstressed, unfooted syllable of *banána* does not fit the S-(w) template and is therefore omitted.

This template account can also apply to children's longer words. In a nonword repetition study by Gerken (1994a), two-year-olds were asked to imitate four-syllable nonwords with varying stress patterns (e.g., *zámpakasis*, which has the same stress pattern as *cátamaran*, or *pazámkasis*, which has the same stress pattern as *divérsify*). Children reduced the *pazámkasis* forms more often by omitting the initial syllable (*zámkasis*), and reduced the *zámpakasis* forms more often by omitting the third syllable (*zámpasis*). In the *pazámkasis* case, the initial weak syllable does not conform to the S-(w) foot template and is therefore omitted. In the case of *zámpakasis*, the first weak syllable belongs to a trochaic foot (*zámpa*), while the second weak syllable (*ka*) is unfooted, and hence omitted.

The third account of children's truncations is based on the argument that children's perceptual systems have a strong bias to detect stressed or word-final syllables in the input and to ignore pretonic weak syllables (Blasdell & Jensen, 1970; Echols, 1993; Echols & Newport, 1992; Klein, 1981; Slobin, 1973). Syllables with primary stress have higher pitch, longer duration, and greater amplitude than the surrounding syllables (Echols & Newport, 1992; Lehiste, 1970), thus children may be better able to perceive and encode these syllables. Under such an account, weakly stressed syllables are omitted because they are less likely to be fully encoded to begin with. The salience of final syllables is insufficiently explained, but may be derived from acoustic cues related to phrasal boundaries, such as word-final lengthening effects (Echols & Newport, 1992; Klatt, 1976; Oller, 1973; Umeda, 1975; Vihman, 1996), or better encoding of final chunks of an utterance than initial chunks due to the possibly shorter attention and memory spans of children (Aitchison, 1972; MacKay, 1970; Slobin, 1973). Alternatively, it is the case that much of children's input also contains a function word + noun combination. Since many of the early nouns that infants hear are monosyllabic, a disyllabic iambic stress pattern is created through this syntactic combination (e.g., 'the + dog') that is a very common perceptual pattern to infants' ears (Vihman, DePaolis & Davis, 1998).

Finally, the fourth account is similar to the perceptual account of stress and right-side bias, but is phonologically motivated (Archibald, 1995; Kehoe, 1999/2000; Kehoe & Stoel-Gammon, 1997b; Pater & Paradis, 1996). Kehoe and Pater and Paradis have

formalized the proposal within the framework of Optimality Theory, positing high-ranked constraints in young children's grammars that place an emphasis on the primary stressed syllable and the right side of the word. In motivating this account, Kehoe states that the crucial examples are those few words in children's vocabularies that are four or five syllables long. With targets of two or three syllables, effects of a right-sided bias are difficult to dissociate from effects of a prosodically-based mechanism. For example, a wSw form might be reduced to a Sw form, but it is ambiguous whether this reduction is due to a constraint on prosodic word shape or faithfulness to the right word edge. In Kehoe's (1999/2000) study, disyllabic outputs of four- and five-syllable targets most often included the right-most foot, regardless of whether it contained the primary or secondary stressed syllable (e.g., [kádo] for *àvocádo*, [káptɚ] for *hélicòpter*, [gédɚ] for *álligàtor*, Kehoe, 1999/2000: 39). Outputs containing more than two syllables also preserved the stressed syllables and the final foot or syllable (e.g., [hákàpɚ] for *hélicòpter*, [hìpopámɪs] for *hìppopótamus*, Kehoe, 1999/2000: 40).

The debate surrounding the mechanism(s) behind children's word truncations extends to cross-linguistic research as well. In fact, one of the relevant issues is whether children's patterns of reducing words are grounded in language universals, or whether they are based on language-specific information. This question is beyond the scope of this paper. However, it is worth noting some cross-linguistic research efforts in the study of children's truncation. Word truncations are as prevalent among toddlers of other languages as they are among English-speaking children. And, just as with English-speaking children, non-English-speaking children demonstrate particular patterns of omission or preservation in their word reductions. For instance, the tendency for young children's productions to take on a well-formed disyllabic trochaic shape is documented for Dutch (Fikkert, 1994; Wijnen, Krikhaar & den Os, 1994), Sesotho (Demuth, 1996), and Japanese (disyllabic forms with more heavy-light syllable patterns than light-heavy; Ota, 1998).[1] The preference for children's truncated forms to maintain the primary stressed syllable and final syllable(s) of a target word has been found for Dutch (Fikkert, 1994; Wijnen, Krikhaar & den Os, 1994), Sesotho (Demuth, 1996), French (Paradis, 2001), and the related preference for children's truncated forms to omit initial unstressed syllables has been found for Dutch (Fikkert, 1994; Wijnen, Krikhaar, & den Os, 1994), Spanish (Gennari & Demuth, 1997; Vihman, 1980), and Estonian, Czech, and Slovenian (Vihman, 1980). Finally, the preference for children's truncated forms to maintain the primary stressed syllable, and initial syllable (as opposed to final syllable) has been documented for Russian (Voeykova, 1997).

In summary, the studies on children's word reductions overwhelmingly suggest that when children omit syllables from polysyllabic words, they follow patterns based on stress and word position. With regard to stress, children preserve the primary stressed syllable of a word but omit weakly stressed or unstressed syllables. With regard to word position, they show a tendency to preserve the final syllable (at least among English-speaking children). Finally, with regard to either stress or word position, children tend

[1] See also Archibald (1996), Hochberg (1988), Paradis (2001), Vihman (1996), and Vihman, De Paolis & Davis (1998) for discussion of the debate about a universal trochaic hypothesis in children's language acquisition.

to omit word-initial unstressed syllables. Although stress and syllable position are key factors influencing English-speaking children's word reductions, there are others as well, such as the segmental content of the word (Kehoe & Stoel-Gammon, 1997a), the number of syllables in an utterance (Gerken, 1996), and the lexical familiarity of the utterance (Boyle & Gerken, 1997; Ohala & Gerken, 1997).

1.2 *Word reduction by adults*

English-speaking adults' behavior with regard to word truncations may also provide insight into the nature of word reductions in children with normally developing language. In adult speech, word truncations are found most commonly in casual to fast speech registers and in abbreviations in word formation. In casual and fast speech, reductions are most often formed either by unstressed medial vowel deletion (syncope) as in *célery* ~ *célry* and *chócolate* ~ *chóclate* (Dalby, 1985; Zwicky, 1972), or by unstressed initial syllable deletion (aphaeresis) as in *becáuse* ~ *cáuse* or *afráid* ~ *fráid* (Fisher & McDavid, 1973; Kypriotaki, 1970). Abbreviation in word formation typically results from whole syllable deletions (clipping). There are four possible types of clipping: fore-clipping (e.g., *mícrofìche* ~ *fìche*), back-clipping (e.g., *lìmosíne* ~ *límo*), mixed (e.g., *ìnfluénza* ~ *flú*), and compounds (e.g., *pósitron* ~ *pósitive eléctron*; Marchand, 1969). Back-clipping is by far the most common type of clipping in English, followed by fore-clipping, with the other types occurring only rarely (Bareš, 1974; Hamans, 1996; Kreidler, 1979; Szpyra, 1995). This preference shown by adults for retaining the left-most portion of the word in abbreviations stands in contrast to the preference discussed above for children to preserve right edges of words when syllables are omitted.

While these kinds of word reduction are frequent in English and certain large-scale patterns have been reported in surveys of speech corpora, few systematic experiments have been carried out. In fact, researchers have been largely unable to provide specific rules for predicting how certain words will be shortened. For example, whether initial syllables or final syllables would be clipped (e.g., *président* ~ *prés* vs. *télephòne* ~ *phóne*), how many syllables would be deleted, or whether whole syllables or just vowels would be deleted are all largely unpredictable variables in word reduction behavior by adults. Despite the lack of a predictable reduction process among English-speaking adults, however, researchers have noted a number of trends that appear in both word abbreviation and word reduction in fast or casual speech. Kreidler (1979) and Hamans (1996) both found a preference for abbreviated words in English to take the form of a monosyllable with a coda or a disyllable without a final coda. Kreidler also found that abbreviated forms often contain prominent parts of the full form, such as the initial syllable or a syllable bearing stress, although he notes that this does not necessarily correspond to the syllable bearing main stress. Szpyra (1995) noted that clipped forms in English tend to correspond to a well-formed prosodic foot (either monosyllabic or disyllabic) and that in cases where initial clipping occurs, the truncated form typically begins with the syllable bearing primary stress in the full form.

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 for 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, and often falls into certain segmental contexts (e.g., preceding a sonorant consonant). In a comparison between a corpus of television news interviews and a second corpus of three participants producing both slow and fast versions of test sentences, Dalby (1985) found that in conversational and very fast speech, syllable deletion (or vowel deletion) occurs more often when the syllable is unstressed and in certain positions in the word (e.g., word-medial and poststress) than when it is stressed or in other positions in the word (e.g., word-initial or word-final).

In one of the few experimental approaches to adult abbreviation behavior, Bell Laboratories employees were asked to abbreviate written computer command names (Streeter, Ackroff, & Taylor, 1983). Streeter et al. found that polysyllabic words were most often shortened by truncation of the final syllable(s). In an earlier series of experiments on written word abbreviation behavior, Hodge and Pennington (1973) found that with shorter words, participants more often omitted word-medial syllables and segments, whereas with longer words, participants more often omitted word-final syllables and segments.

Cross-linguistic research on reduced forms suggests a strong tendency for adult truncations to result in the maintenance of salient syllables and in well-formed feet, regardless of input word length or stress pattern. In one of the only studies looking at the role of stress in clippings, a preference for maintaining the primary stressed syllable in the truncated form was found by Piñeros (2000) for Spanish. The preference for disyllabic truncated forms has been reported for Spanish (Colina, 1996), French (Kilani-Schoch, 1996), Italian (Thornton, 1996), Catalan (Cabré, 1994), Japanese (Itô, 1990; Mester, 1990), German (Ronneberger-Sibold, 1995), and Hungarian (van de Weijer, 1989).

The combined efforts of researchers looking at corpora of word reduction behavior and researchers looking at word abbreviation in the laboratory have revealed that there is a substantial amount of variability in the patterns of truncation and abbreviation behavior both within and across individuals. However, some systematic patterns, such as a preference for maintaining word onsets and other salient parts of the word (e.g., word endings and stressed syllables), and a preference for output patterns such as monosyllables and disyllables, have been found repeatedly in both the corpus-based and the experimental-based studies.

A number of experimental studies in the domain of language processing have also shown that word onsets, word endings, and stressed syllables play a key role in lexical access, word recognition, and speech processing. Evidence for the salience of word onsets in language processing comes from lexical decision studies (e.g., Taft, 1979; Tyler, Marslen-Wilson, Rentoul, & Hanney, 1988), shadowing tasks (e.g., Marslen-Wilson and Welsh, 1978), the gating paradigm (e.g., Grosjean, 1980; Nooteboom, 1981), phoneme monitoring (e.g., Schriefers, Zwitserlood, & Roelofs, 1991), and studies of induced tip-of-the-tongue states (e.g., Brown & McNeill, 1966). The evidence for left-to-right processing of words in the auditory domain is in fact so robust that some models of word recognition, such as Cohort Theory (Marslen-Wilson, 1984) and Cole and Jakimik's (1980) model are based on the assumption of sequential processing of phonemes.

As discussed above, however, English-speaking children tend to rely on the right edges of words in language processing. While there is an abundance of research suggesting a left edge bias in adults, there is also evidence that word endings are more salient for adults than word middles, based on studies in visual word recognition (Bruner & O'Dowd, 1958), the tip-of-the-tongue phenomenon (Brown & McNeill, 1966), and auditory gating tasks (Nooteboom, 1981). Together, these previous studies suggest that both word onsets and word endings are relevant in adult language processing. Based on these and similar findings, Hawkins and Cutler (1988) argue that the relative salience of word endings over middles warrants reconsideration of strict left-to-right models of word recognition.

Evidence for the importance of stress in word segmentation in language processing comes from phoneme monitoring studies (Mattys & Samuel, 2000) and nonword segmentation tasks (Cutler & Norris, 1988). This research has also provided results that suggest that models of lexical access need to include some reference to stress and its role in segmentation (Bradley & Forster, 1987; Grosjean & Gee, 1987; Mattys, 1997). Cutler and her colleagues even proposed a model of continuous speech segmentation based on stress called the Metrical Segmentation Strategy (Cutler, 1990; Cutler & Carter, 1987).

Word onsets, word endings, and stressed syllables all seem to play a role in word truncation and abbreviation behavior by English-speaking adults. They are also relevant in lexical access and word recognition. It therefore appears that word-initial syllables, word-final syllables, and stressed syllables are salient pieces of words and that, due to their salience, they are used when creating abbreviated forms in writing and in lexical access for lexicon searches and segmentation. One of the goals of this study was to determine what the roles of word onsets, word endings, and stressed syllables are in an auditory-oral word reduction task. Given the role of these salient syllables in lexical access and written abbreviation, we predicted that they would also play an important role in oral word reduction.

The goals of this study were therefore twofold. The first goal was to examine adult word reduction behavior in order to compare it to the word reduction behavior exhibited by normally developing children. The second goal was to examine word reductions in a large group of adults in order to identify patterns of reduction for a variety of polysyllabic word types. Specifically, this project was designed to be an exploratory, systematic study of the effects of two target word factors (primary stress position and syllable number) on adults' reduction outputs. Additionally, we were interested in providing further evidence for the role of word edges and stressed syllables in language processing, and in identifying any predictable variability between participants. Based on the conclusions made in the adult studies reviewed above and the findings in the studies with children, we made several predictions regarding reductions in this experiment. The first prediction was that regardless of primary stress placement 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 primary stress on the first syllable. The second prediction was that the salient syllables would be preserved. In particular, the primary stressed syllable, the initial syllable, and the final syllable should be preserved in responses more often than omitted. The third prediction was that,

based on the child data, initial syllables should be omitted more often if they directly precede primary stress.

2 Experiment

2.1 Method

Participants. Twenty-seven undergraduates (6 males and 21 females) were recruited from the Indiana University community. All participants received partial course credit towards an Introductory Psychology class for their participation. The mean age of these participants was 19.19 years ($SD = 1.65$). Data from five participants were not included in the final analysis due to: being a non-native speaker of English (one participant), having a history of speech disorder (one participant), and failing to comply with experimental instructions (three participants). The remaining 22 participants whose data were included were 6 males and 16 females (mean age of 18.91, $SD = 1.23$), who were native speakers of English and had no history of speech or hearing disorders.

Stimulus materials. The stimuli consisted of 160 polysyllabic monomorphemic words that varied systematically in the number of syllables and location of primary stress.[2] Stimulus words 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 within one standard deviation of the log mean frequency of the target category (based on values given in Kučera & Francis, 1967); second, a neighborhood density of two 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).[3]

Stimuli were coded for primary stress position (and not for secondary stress) based on the bulk of literature cited above that suggests a perceptual or production salience of the syllable that bears primary stress. Additionally, there exists some controversy around the treatment of secondary stressed syllables, and even as to what constitutes a secondary stressed syllable, either perceptually or acoustically (Cutler, 1986; Fear, Cutler, & Butterfield, 1995; Mattys, 2000; Vroomen & de Gelder, 1997). Weak syllables that are reduced to a schwa are generally considered to be unstressed. However, the treatment of weak syllables that are unreduced, that is, which contain a full vowel (e.g., the initial syllable of *automata* or *bandana*), is not as clear. For instance, the initial syllable of *bandana* has been described as bearing secondary stress by Hammond (1999, p. 148) but as bearing no stress by Schane (1979, p. 561). Additionally, Beckman and Edwards (1994) cite examples of individual variability in the pronunciation of certain weak

[2] Stimuli were judged to be monomorphemic based on the absence of any productive prefixes or suffixes (Bybee, 1985).

[3] Familiarity was set at 6.5 and above for all categories except trisyllabic and quadrisyllabic words with primary stress on the third syllable, 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.

vowels, citing alternations between reduced and full lax vowels. Furthermore, we would have been unable to control for word frequency, familiarity, and neighborhood density, and maintain the number of words in each target category, had we controlled also for possible secondary stress effects. Therefore, in order to avoid the controversy in this initial study of adults' word reductions, and to maintain our other control measures, the prosodic control was limited to inclusion of the position of primary stress. We will return to the issue of secondary stress in the General Discussion.

As shown in Table 1, there were eight target categories, each with 20 words. The target categories were coded according to the number of syllables in each word (two, three, or four) and where primary stress occurred (first, second, or third syllable). Thus, the target categories were 2–1 (disyllabic words with primary stress on the first syllable), 2–2 (disyllabic words with primary stress on the second syllable), 3–1 (trisyllabic words with primary stress on the first syllable), and so on.[4]

TABLE 1

The eight stimulus target categories, the number of syllables in each category, and the syllable that bears primary stress for each category

Target Category	*Number of Syllables*	*Primary Stress Location*
2–1	2	1st
2–2	2	2nd
3–1	3	1st
3–2	3	2nd
3–3	3	3rd
4–1	4	1st
4–2	4	2nd
4–3	4	3rd

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 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 that included the entire visible speech signal in both the waveform and the spectral view such that each file started and ended at a

[4] There were only 39 quadrisyllabic words with primary stress on the fourth syllable, and even fewer that also met our other criteria, therefore we did not include this pattern in the stimulus set.

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, as if they were creating a new slang with their friends. College students have long been identified as one subgroup of the population who has a tendency to create abbreviations on the fly as a sign of in-group solidarity (Gonzales, 1992; Schultz, 1929). An auditory-oral reduction task was selected over a written task in order to avoid possible orthographic effects and to encourage the participants to create abbreviations or clippings, as opposed to acronyms, in their reductions. The participants were provided with examples (e.g., *hìppopótamus ~ hippo*; *biólogy ~ bio*; *opóssum ~ póssum*) and reminded that most of the words would not be normally reduced in everyday speech.[5] The participants then had 5.5 s to carry out both tasks, that is, repeat 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 randomly 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 described above. 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 48 kHz (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.

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 participant'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 primary stressed syllable was preserved (either as the stressed syllable or as a

[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.

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 nonresponses, misperception of the stimulus, a shift in primary stress in the repetition of the stimulus (e.g., repeating the target *tàngeríne* as *tángerìne*), and any phonologically unrelated reductions of the target (e.g., reducing the target *cònstellátion* to *stárs*).

2.2 *Results*

Examples of several target stimuli and participant responses are given in Table 2. The first column represents the syllable number and primary stress location of each target category, and the second column shows a corresponding example word. The third column shows a typical example of participants' repetition responses for each stimulus word, transcribed using the IPA. The fourth column shows one possible reduction response for each repetition, also transcribed in IPA. The example reduction responses are not intended to reflect the most common responses or the predicted responses, but rather simply to provide one of the many responses that the participants actually produced for each target word. For example, the second row, 2–1, shows one possible response for the target word *máple*, which has two syllables and primary stress on the initial syllable: a repetition, [méɪpl̩], followed by a reduction, [méɪp].

TABLE 2

Examples of stimulus words, repetition responses (in IPA), and reduction responses (in IPA) for each target category. Primary stress is marked with an acute accent, ˊ, and secondary stress with a grave accent, ˋ.

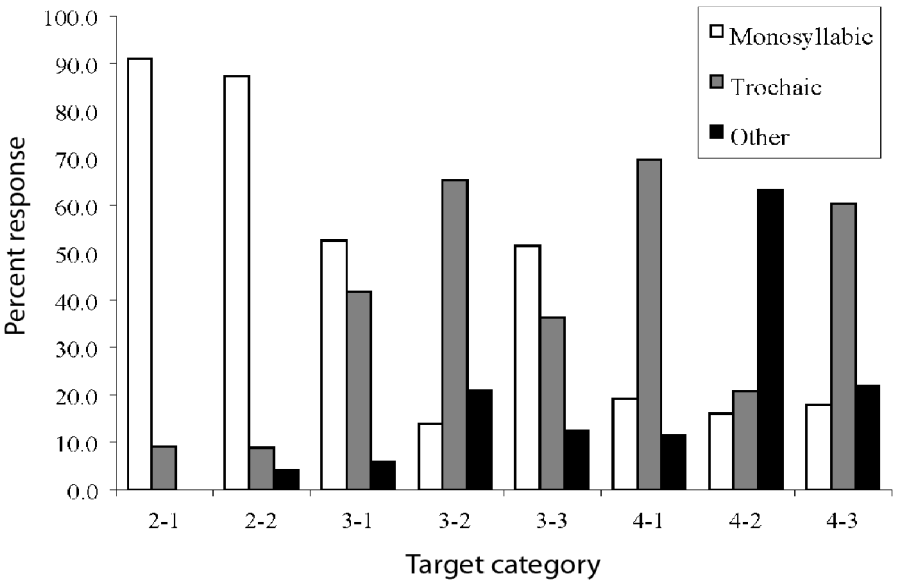
Target category	*Example of stimulus word*	*Example of repetition response*	*Example of reduction response*
2–1	máple	méɪpl̩	méɪp
2–2	gazélle	gəzɛ́l	zɛ́l
3–1	Ámazòn	ǽməzɔ̀n	zɔ́n
3–2	màrtíni	màrtɪ́ni	tɪ́ni
3–3	tàngeríne	tæ̀ndʒərɪ́n	tǽndʒ
4–1	sálamànder	sǽləmæ̀ndɚ	mǽndɚ
4–2	aquárium	əkwɛ́rɪm̩	kwɛ́rɪm̩
4–3	tàpióca	tæ̀pɪóʊkə	tǽpi

The results of reduction response coding for the 22 participants are summarized in Figures 1 through 5. Figure 1 displays results relevant to the 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. The prosodic output patterns

are shown, coded as a monosyllabic foot, such as [méɪp] for *máple*, a disyllabic trochaic (Strong-weak) foot, such as [mǽndɚ] for *sálamànder*, or an *Other* response. The *Other* response category included disyllabic reductions with second syllable stress, for example, [əkwɛ́r] for *aquárium*, and all trisyllabic reductions, for example, [kwɛ́riṃ] for *aquárium* or [pióʊkə] for *tàpióca*.

Figure 1

Percent of reduction responses that contained a monosyllabic foot, a disyllabic trochaic foot, or *Other* output pattern for each target category



Across categories, participants reduced words significantly more often to a monosyllabic foot than to a disyllabic foot or an *Other* form ($\chi^2 = 8.49$, $df = 1$, $p < .01$ and $\chi^2 = 377.91$, $df = 1$, $p < .001$, respectively), and significantly more often to a disyllabic foot than to an *Other* form ($\chi^2 = 278.32$, $df = 1$, $p < .001$). Out of the eight target categories, seven categories were reduced by participants most often to either a monosyllabic foot or a disyllabic foot. Four categories were reduced by participants most often to a monosyllabic foot. First, the 2–1 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 2–2 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]).

The 3–1 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 3–3 target category was reduced significantly more often to a monosyllabic foot, as in *bàssinét* ~ [nét] (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 3–2 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 ($\chi^2 = 142.35$, $df = 1$, $p < .001$). In addition, the 3–2 category resulted in a disyllabic foot significantly more often than an *Other* pattern, which occurred in 20.9% of responses ($\chi^2 = 98.86$, $df = 1$, $p < .001$). This reduction response pattern was due to omissions of the initial, preprimary stress syllable (see Fig. 5), as we predicted. The 4–1 and 4–3 target categories demonstrated similar results for output reductions, with a disyllabic foot reduction in 69.5% and 60.4% of responses, respectively (e.g., *córonàry* ~ [kɔ́roʊ], and *èpidémic* ~ [dɛ́mək]). Both of these patterns occurred more often than a monosyllabic pattern ($\chi^2 = 122.95$, $df = 1$, $p < .001$ for 4–1 and $\chi^2 = 99.37$, $df = 1$, $p < .001$ for 4–3), or an *Other* pattern ($\chi^2 = 180.52$, $df = 1$, $p < .001$ for 4–1 and $\chi^2 = 76.70$, $df = 1$, $p < .001$ for 4–3). In looking at reductions of these seven target categories, longer target words tended to be reduced more often to a disyllabic form, whereas shorter target words tended to be reduced more often to a monosyllabic form.

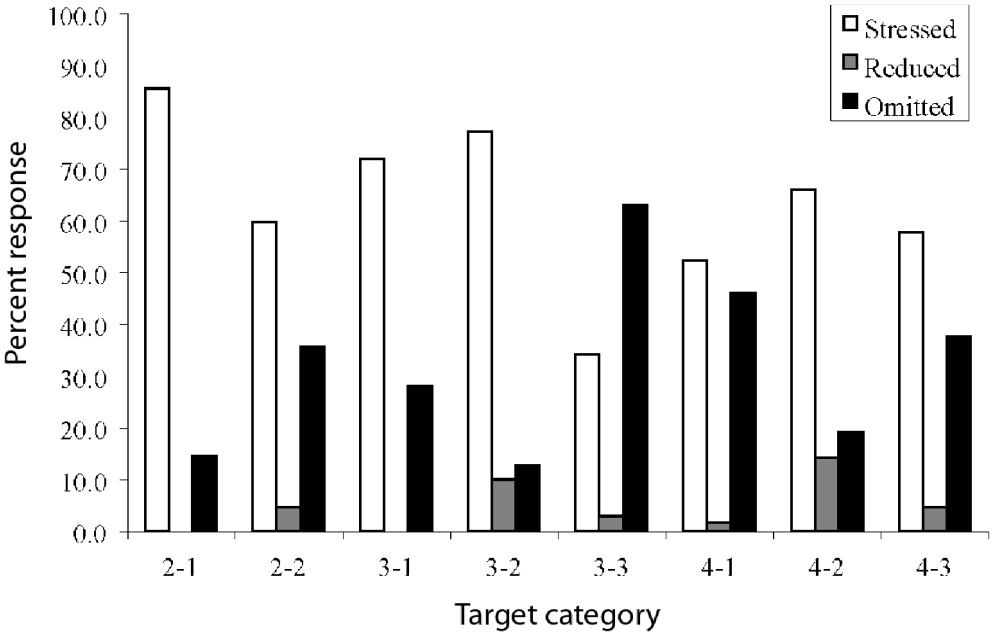
Only the 4–2 category was notably reduced most often to the *Other* category, in 63.2% of responses, whereas it was reduced to a monosyllabic foot in 16.0% of responses and to a disyllabic foot in 20.7% of responses. The differences between an *Other* response and a monosyllabic foot response, and an *Other* response and a disyllabic foot response, were significant ($\chi^2 = 123.36$, $df = 1$, $p < .001$ and $\chi^2 = 93.77$, $df = 1$, $p < .001$, 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* ~ [kwɛ́riṃ]). In sum, the reduction responses were generally consistent with our first prediction, and suggest that adults reduce words to a prosodically well-formed output (either a monosyllabic or disyllabic foot). This overall pattern of responses was consistent with the prior research discussed above on children's and adults' word reduction behavior.

The second prediction involved the preservation of salient syllables (primary stressed, word-initial, and word-final). First, we predicted that participants' patterns of reduction responses would retain the primary 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* ~ [tɨ́ni]), responses that included the primary stressed syllable in a reduced, unstressed capacity (in which primary stress has been shifted to another syllable, e.g., *màrtíni* ~ [márɾi]), and responses in which the primary stressed syllable was omitted altogether (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 ($\chi^2 = 1720.17$, $df = 1$, $p < .001$). However, there were also significantly more responses that contained an omission of the original primary stressed syllable (ranging from 12.8% to 62.9%) than retained it as a reduced syllable ($\chi^2 = 346.42$, $df = 1$, $p < .001$). The small percentage of primary stressed syllables resulting in a reduced syllable comes from the relatively small percentage of cases involving a shift in primary stress from one syllable to another, for example *tíger ~ gér*. Across the three word length types (disyllabic, trisyllabic, quadrisyllabic), target categories with primary stress on the first syllable had the fewest shifts in primary stress (0% to 1.6%), and target categories with primary stress on the second syllable had the most shifts in primary stress (4.7% to 14.2%).

Figure 2

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



Four patterns were noteworthy regarding primary stressed syllables that were preserved as the primary stressed syllable. First, there was a difference between the reduction responses for the two disyllabic target categories. For the 2–1 category, the primary 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 primary stressed syllable was statistically significant ($\chi^2 = 213.18$, $df = 1$, $p < .001$). In contrast, for 2–2 words, the primary stressed syllable was preserved as the primary 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 the frequency of each of the three possible outputs to be statistically different from the others. That is, the difference between preservation of the primary stressed syllable as stressed and the primary stressed syllable in a reduced form ($\chi^2 = 199.84$, $df = 1$, $p < .001$), the difference between preservation of the primary stressed syllable as stressed and omission of the primary stressed syllable ($\chi^2 = 25.06$, $df = 1$, $p < .001$), and the difference between preservation of the primary stressed syllable as reduced and omission of that syllable ($\chi^2 = 102.25$, $df = 1$, $p < .001$) were all significantly different. The high rate of preservation of the primary stressed syllable as the stressed syllable, together with a lack of occurrence of the primary stressed syllable as reduced in 2–1, reflects the bias for content words to have initial syllable stress in English. In addition, the small percentage of preservation of the primary stressed syllable as a reduced syllable in the 2–2 target words was primarily due to a shift in primary stress position to the initial syllable, as in *adápt* ~ [ǽdəp].

A second finding of interest was the pattern of responses for the target category 3–1. The primary stressed syllable was preserved in its stressed form in 71.9% of word reductions, significantly more often than it was omitted, in 28.1% of reductions ($\chi^2 = 82.12$, $df = 1$, $p < .001$). Again, as in the 2–1 category, there were no productions in which the initial syllable was reduced, suggesting that the participants maintained the initial stressed syllable of the target as the most salient syllable in their reductions.

Third, the primary stressed syllable was preserved as the stressed syllable least often of all target categories for 3–3, at 34.2% (an example of a more frequent reduction response for this target category was [síloʊ] 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 Fig. 3). In fact, the finding suggests that although stress and final syllable position have both been shown to be prominent factors in word reduction, in some cases the initial syllable is more likely to be preserved, regardless of primary stress position. This finding will be revisited in the following sections.

The fourth noteworthy response pattern occurred with the target category 4–1. Contrary to expectations, the primary stressed syllable was not consistently maintained in reductions. The primary 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 resulting output pattern of the preservation of one of the two prosodic feet and the omission of the other, for example as in *mátrimòny* ~ [mǽtri] or [móʊni]), becomes even more evident in Figure 3.

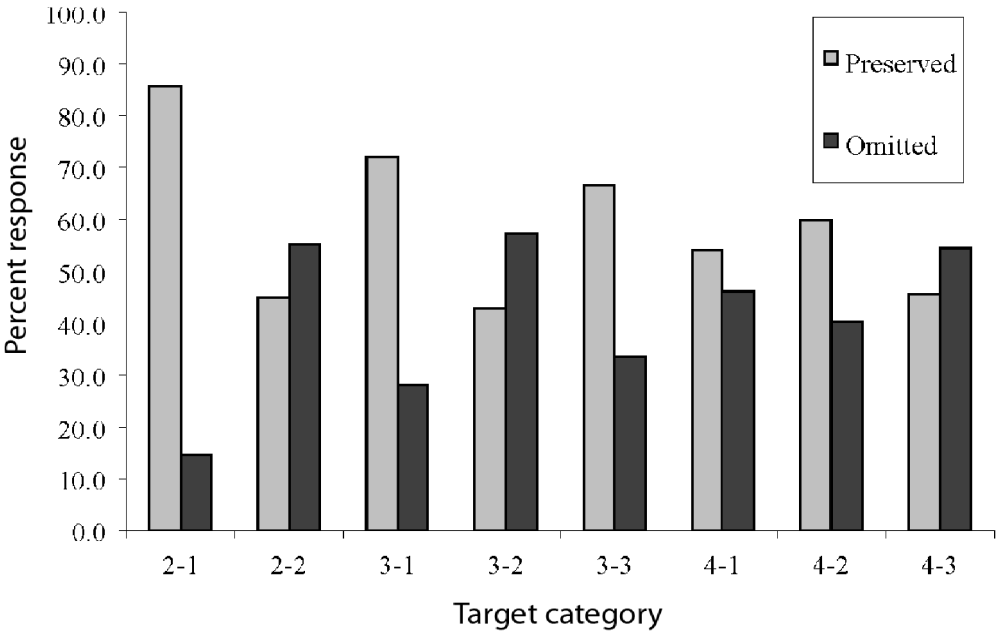
In sum, the overall consistent finding that participants faithfully maintained the primary stressed syllable as the stressed syllable in their reduction responses supports earlier findings reported by Cutler and Carter (1987), Echols (1993) and Echols and Newport (1992) on the salience of stressed syllables. However, it seems that the position

of primary stress in the word, relative to the number of syllables, affects this preference for maintaining the stressed syllable.

With regard to word-initial syllables, as with primary stressed syllables, the 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.

Figure 3

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



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 the categories 2–1 ($\chi^2 = 213.18$, $df = 1$, $p < .001$), 3–1 ($\chi^2 = 82.12$, $df = 1$, $p < .001$), 3–3 ($\chi^2 = 46.67$, $df = 1$, $p < .001$) and 4–2 ($\chi^2 = 16.26$, $df = 1$, $p < .001$). The results for the 2–1 and 3–1 categories suggest that primary stress, especially when it falls on the initial syllable, is a good predictor of the preservation of that initial syllable in word reductions of disyllabic and trisyllabic words. The reduction response pattern for the target category 3–3 (66.5% preservation rate of the initial syllable) was unexpected, given that the target category has final syllable stress. This result may point to a possible preference for the participants to preserve the word-initial syllable over the word-final syllable, despite the fact that the final syllable carries main stress. An alternative interpretation draws on secondary stress. The initial syllable bears secondary stress in each of the words in this

category (e.g., *bàssinét*). Therefore, it may be the case that an initial syllable with secondary stress may be more salient than an unstressed initial syllable typical of, for example, 3–2 targets. The preservation of initial syllables for the 4–2 category was due to disyllabic iambic reduction patterns such as *aquárium* ~ [əkwɛ́r] (see Fig. 1).

Our prediction was not borne out for four target categories, however: 2–2, 3–2, 4–1, and 4–3. For the categories 2–2 and 3–2, 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 (2–2) or the final disyllabic foot (3–2). These patterns were identical to typical omissions of the weak initial syllable found in normally developing children and support our third prediction regarding the omission of initial syllables directly preceding primary stress. Further evidence in support of this prediction is discussed below (see Fig. 5). The categories 4–1 and 4–3 showed no statistical difference between preservation and omission of the initial syllable (54.0% preservation for 4–1 and 45.6% for 4–3). These results suggest once again that for the 4–1 category, as well as for 4–3, participants omitted one of the two prosodic feet and preserved the other when reducing these categories. In summary, in support of our prediction, initial syllables were preserved more often than they were omitted for four of the eight target categories. In two of the remaining four categories (2–2 and 3–2), the results suggest that adults as well as children omit initial syllables when the second syllable bears primary stress. In the other two categories (4–1 and 4–3), the omission of the initial syllable corresponds to the first prediction regarding a preference for disyllabic trochaic outputs, which can be formed from 4–1 and 4–3 words through either omission of the first two syllables or omission of the last two syllables.

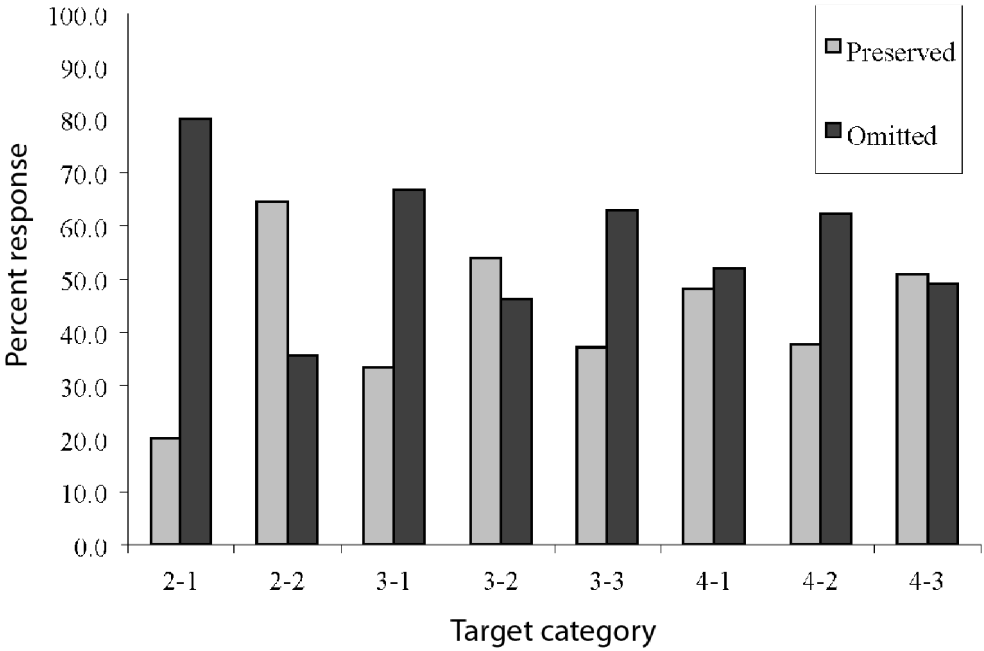
Figure 4 (overleaf) shows the mean response percentages for final syllable preservation and omission in word reduction. With regard to final syllables, the predicted outcome was that final syllables would also be preserved more often than omitted. However, there was only one category for which the predicted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

For five target categories, the final syllable was omitted significantly more often than it was preserved: 2–1, 3–1, 3–3, 4–1 and 4–2. The result obtained for the 2–1 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 3–3 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, 3–2 and 4–3. Taken together, the results for final syllable preservation suggest that for adults the final syllable is not as salient as stressed or initial syllables are, except in the case of 2–2 (where fewer strategies exist to reduce words).

A final interesting note regarding salient syllables is the distribution of initial and final syllable preservation responses for 2–1 and 2–2 target words. 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

Figure 4

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



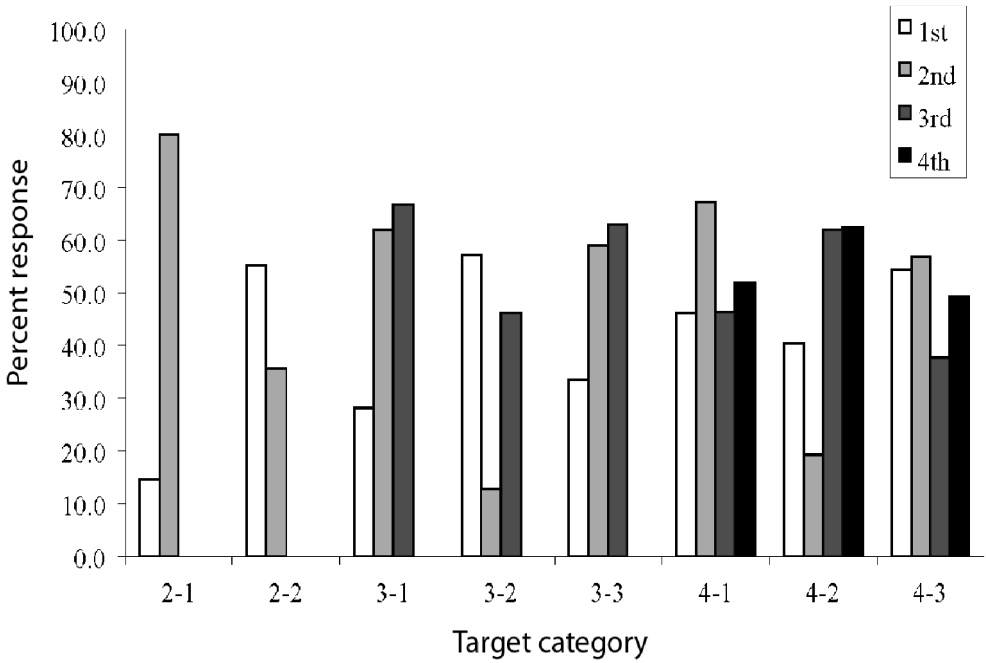
of preservation was in the opposite direction (2–1 words showed a higher percentage of preservations of the initial syllable and 2–2 words showed a higher percentage of preservations of the final syllable), the rates of preservation were noticeably different (85.5% initial and 20.0% final for 2–1 vs. 44.8% initial and 64.4% final for 2–2). A similar response distribution was found for the 3–1 and 3–2 targets (71.9% initial and 33.3% final for 3–1 vs. 42.8% initial and 53.9% final for 3–2). These patterns once again reflect the tendency for English content 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.

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. This pattern is found in children's productions as well as some adult abbreviations, and so should not be a surprising prediction. The prediction was supported for two target categories 2–2 and 3–2, yielding responses that were similar to children's productions (e.g., *gazélle* ~ [zɛ́l] and *màrtíni* ~ [tíni]). For disyllabic words, the pretonic initial syllable in the category 2–2 was omitted significantly more often than the stressed initial syllable in the 2–1 category ($\chi^2 = 100.77$, $df = 1$, $p < .001$). For trisyllabic words,

Figure 5

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



the pretonic initial syllable in 3–2 words was omitted significantly more often than the initial syllable in 3–1 and 3–3 words ($\chi^2 = 41.0$, $df = 1$, $p < .001$ and $\chi^2 = 29.11$, $df = 1$, $p < .001$, respectively).

The prediction was not supported for 4–2 targets, however. That is, there was no difference between percentage of omissions of the initial syllable from 4–2 and 4–1 targets. The pretonic initial syllable in the 4–2 category was in fact omitted significantly less often than the initial syllable in the 4–3 category ($\chi^2 = 8.78$, $df = 1$, $p < .01$). Possible explanations for this finding will be discussed below.

The data from the three analyses are summarized in Tables 3 through 5 to 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 most common output foot pattern (whether monosyllabic, i.e., 'S,' disyllabic and trochaic, i.e., 'Sw', or *Other*), whether or not the primary stressed syllable was preserved as the stressed syllable more often than preserved as reduced or omitted, whether or not the initial syllable and final syllable were preserved more often than omitted, and the syllable or syllables that were omitted most often in the word reduction responses.

TABLE 3

Summary of results for reduction responses for 2–1 and 2–2 target categories

Target category	*Most common output prosodic pattern*			*Stressed syllable 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*
2–1	✔			✔	✔			✔
2–2	✔			✔		✔	✔	

TABLE 4

Summary of results for reduction responses for 3–1, 3–2, and 3–3 target categories

Target category	*Most common output prosodic pattern*			*Stressed syllable 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*
3–1	✔			✔	✔			✔	✔
3–2		✔		✔			✔		
3–3	✔				✔			✔	✔

TABLE 5

Summary of results for reduction responses for 4–1, 4–2, and 4–3 target categories

Target category	*Most common output prosodic pattern*			*Stressed syllable 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*
4–1		✔						✔		
4–2			✔	✔	✔				✔	✔
4–3		✔		✔			✔	✔		✔

3 General Discussion

TABLE 6

The eight stimulus target categories, the possible stress patterns in each category, and the number of target words in each category with each of the stress patterns. (S = primary stress, *s* = secondary stress, and *w* = reduced/zero stress)

Target Category	*Stress Pattern*	*Number of Targets*
2–1	Sw	17
	Ss	3
2–2	wS	14
	sS	6
3–1	Sww	10
	Sws	10
3–2	wSw	11
	sSw	9
3–3	swS	20
4–1	Swsw	20
4–2	wSww	11
	sSww	4
	wSws	3
	sSws	2
4–3	swSw	20

The analyses performed on the word reduction data that were collected in this task suggest that the relationship between word length, primary stress location, and adult word reduction behavior is complex. Our first prediction was that participants would reduce words to a well-formed prosodic foot, regardless of target length or stress pattern. Our prediction was borne out for seven of eight target patterns. That is, the participants more often than not reduced words to a foot that was either monosyllabic or disyllabic. The finding that more reduction responses took the form of a monosyllabic foot than any other form results most strongly from the responses for the disyllabic target forms. That is, when asked to reduce a disyllabic target, the most reasonable way to do so was to delete one syllable, leaving a monosyllabic foot. The categories 3–1 and 3–3 were the remaining categories that were reduced most often to a monosyllabic foot. The most common monosyllabic responses in both categories contained either the primary stressed syllable (the initial syllable in 3–1, the final syllable in 3–3) or the secondary stressed syllable, if there was one. All of the words in 3–3 carried secondary stress on the initial syllable, and 10 of the words in 3–1 carried secondary stress on the final syllable (see Table 6). This pattern possibly reflects the salience of the syllable that bears secondary stress, and we will return to this issue below. The results from the first analysis confirm those reported by Hamans (1996), Kreidler (1979), and Szpyra (1995) in their discussions of word

formation through abbreviation in which they all found that monosyllabic and disyllabic trochaic feet were the most common output forms for abbreviations in English. Therefore, the word reduction behavior exhibited by our participants in an on-line task reflects the tendencies of word formation by clipping in English.

Our prediction was not borne out, however, for the 4–2 target category. Specifically, word reductions of the 4–2 targets were more often reduced to some other output pattern (as in [əkwér] or [kwériṃ] for the target *aqúarium*). It could be the case that the [əkwér]-type responses were the result of a bias to preserve the initial syllable and the stressed syllable. Kreidler (1979) discussed the occurrence in English of iambic disyllabic clipped forms of 4–2 target words, such as *legít ~ legítimate* or *exéc ~ exécutive*. The participants in this study may have been modeling their responses in this category on these examples of actual abbreviations in English in which a 4–2 target word is reduced by back-clipping to a disyllabic form with primary stress on the second syllable. Likewise, the [kwériṃ]-type responses may have resulted from a tendency to omit the initial weak syllable. These outputs are consistent with Szpyra's (1995) analysis of clipping in English in which she included trisyllabic feet with an initial stressed syllable among well-formed feet in English. Trisyllabic clippings must be formed from target words with at least four syllables and are therefore more rare in English than monosyllabic or disyllabic clippings, but in this controlled task where the participants encountered a proportionally large number of four-syllable words, it could be that they used Szpyra's trisyllabic feet in their reduced forms for the 4–2 targets. In addition, Szpyra (1995) noted that fore-clipping typically involves the omission of all syllables preceding the syllable bearing primary stress in the target word, which is consistent with the [kwériṃ]-type responses for 4–2 targets.

The main findings from the analysis of prosodic output type are also consistent with the literature on children's reductions, discussed above. That is, this population also exhibits a bias for producing well-formed prosodic outputs, specifically a monosyllabic or disyllabic trochaic foot (Demuth, 1995, 1996; Gerken, 1996; Smith, 1973). The trisyllabic clipping found in responses for the 4–2 category is also consistent with two-year-olds' productions of four-syllable words and nonwords with this stress pattern (Gerken, 1994a; Kehoe & Stoel-Gammon, 1997b), in which the stressed syllable and every syllable to the right of the stressed syllable is preserved, while the weak initial syllable is omitted. Therefore, the consistencies between adult reduction behavior in this task and truncation behavior in children indicate a similar emphasis on prosodic well-formedness by both adults and children when forming new words.

Our second prediction was that participants would preserve the salient syllables (primary stressed syllable, initial syllable and final syllable) in their reductions more often than omit them. Three general conclusions can be drawn from the analysis of salient syllables in the reduction responses. First, the primary stressed syllable was overwhelmingly preserved as the stressed syllable in the reduction responses. Second, the initial syllable was preserved more often than it was omitted under certain conditions, including when the initial syllable bore main stress. Third, only when the final syllable of a disyllabic word contained main stress was it preserved more often than it was omitted.

In general, these results support the claims made by researchers in the field of language processing about the role of salient syllables in lexical access and word

recognition. The fact that the primary stressed syllable was preserved in the reduced forms confirms that models of language processing should include some account of the salience of primary stressed syllables, as suggested by Cutler and her colleagues (Cutler, 1990; Cutler & Carter, 1987; Cutler & Norris, 1988). The preservation of initial syllables supports the previous research on a left edge bias in adults and suggests that models of language processing should account for the salience of the left edges of words, although the salience of stress indicates that the models should not involve the strictly left-to-right elimination processes often found in serial models of lexical access (e.g., Cole & Jakimik, 1980; Marslen-Wilson, 1984). Unlike previous studies of language processing that uncovered a salience of word endings over word middles, we found evidence for the preference of maintaining final syllables only for the 2–2 target category.

In addition, the response patterns for the preservation of salient syllables were not consistent across all categories. Specifically, reduction responses of the 3–3 target words contained an omission of the primary stressed (and final) syllable, but a preservation of the initial syllable. The most common reduction responses for the 4–1 and 4–3 target categories were a disyllabic trochaic foot; however there did not appear to be a bias for which foot was preserved. One possible explanation for these variable patterns lies in the domain of stress. The words in each of these three target categories (3–3, 4–1, 4–3) bear secondary stress as well as primary stress (see Table 6), and in each case, secondary stress falls on alternating syllables from primary stress: in the 3–3 target words, secondary stress falls on the initial syllable (as in *càbarét*), in the 4–1 words it falls on the third syllable (*sálamànder*), and in the 4–3 words it falls on the initial syllable (as in *tàpióca*) (Hammond, 1999; Hayes, 1984; Hayes, 1995). Assuming that syllables with secondary stress have more prominence than syllables with zero stress (e.g., the medial syllable of *càbarét*; Beckman & Edwards, 1994; Fear, Cutler, & Butterfield, 1995), it may likewise be the case that syllables with secondary stress are more perceptually or productively salient than unstressed syllables, which may in turn result in the preservation of syllables that contain secondary stress as well as those that contain primary stress. Indeed, a future direction for this line of research would be to specifically examine the role of secondary stress in addition to primary stress in adult word reductions.

The finding that initial syllables are preserved in reduced forms confirms results found in a study of word reduction behavior in French-speaking adults (Rouibah & Tiberghien, 1994). In a laboratory study in which two and three syllable words were presented auditorily and participants were asked to provide written abbreviation responses, Rouibah and Tiberghien found an overwhelming preference for monosyllabic reductions of disyllabic target stimuli and for disyllabic reductions of trisyllabic targets. In both cases, the final syllable was omitted to produce the truncated forms. Therefore, it seems that there is some evidence that onset syllables are salient for adults, regardless of the accent pattern of the native language. Further research on other languages in these kinds of experimental tasks is necessary to confirm the universality of this left edge bias.

The first finding with regard to the preservation of salient syllables corroborates data found for children. As with the adults in this study, children retain the syllable that bears primary stress when they truncate words (Echols & Newport, 1992; Kehoe & Stoel-Gammon, 1997b; Klein, 1981, among others). However, it is interesting to

consider that whereas children place a larger emphasis on preserving the word-final syllable, the adults in this study placed a larger emphasis on preserving the initial syllable. In fact, whereas with 2–2 and 3–3 patterns, in which children would likely preserve the final stressed syllable for its prominent acoustic and perceptual qualities, adults often preserved the first syllable. This apparent transfer in word edge bias may indicate that perceptual or acoustic salience of the word-final syllable only plays a role in development. That is, it might be the case that while children are learning about word segmentation, they place heavy importance on word-final syllables (Echols, 1993), whereas adults already know this word boundary information, and so the salience of final syllables may decrease over time. Other differences that may affect the shift in word edge preservation bias are the possibly smaller attention and memory spans of children than adults, and the left-to-right processing strategies that accompany literacy development.

The role of literacy in word reduction behavior was apparent in some participants' responses in the present study, particularly with respect to orthographic influences. 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 in which participants are asked 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. Despite this auditory presentation, however, there were still a small number of orthographically-based responses due to the inherent link between literacy and language processing in our undergraduate population.

Our third prediction was that initial syllables should be omitted more often if they directly precede primary stress. The analysis of syllable omissions indicates that for disyllabic and trisyllabic words, initial syllables are omitted more often when they directly precede primary stress in the word. However, this was not the case for four-syllable words. As mentioned above, fore-clipping in English typically results in an output form that contains the primary stressed syllable from the target and all of the following syllables. That is, the target is clipped from the beginning of the word until the primary stressed syllable is reached (Szpyra, 1995). The results for the 2–2 and 3–2 target categories in this study reflect this tendency in English word formation. The finding that initial syllables were not omitted more often for 4–2 targets than for 4–1 or 4–3 targets suggests an interaction between the left edge bias discussed above in adult language processing and the omission of initial syllables that directly precede primary stress and reflects reduction responses such as *aquárium* ~ [əkwɛ́r], as discussed above.

The analysis of syllable omissions also revealed more clearly the complex relationship between initial and final syllables and primary and secondary stressed syllables that leads to a complicated set of output patterns. In particular, although the expected complementary omission rate difference existed between 2–1 (in which the final unstressed syllable was omitted more often than the initial stressed syllable) and 2–2 (in which the initial unstressed syllable was omitted more often than the final stressed syllable), this complementary pattern was uneven, with more unstressed syllable omissions occurring for 2–1. This was most likely due to a difference in initial and final syllable preservation that was discussed in previous sections. Second, the high rate of second syllable

omissions from the target category 4–1 was the result of a large number of trisyllabic reductions such as *áppetìzer* ~ [ǽptɑ̀ɪzɚ] or *cémetèry* ~ [sɛ́mtèri], in which the unstressed second syllable, often a schwa, was the only omitted syllable. This result is comparable to the medial vowel deletion, such as [kǽmrə] for *cámera*, found in fast speech registers in adults (Dalby, 1985; Zwicky, 1972). Finally, the similar rates of omission of the second and third syllables from the 3–1 target category (61.9% and 66.7%, respectively) suggest that when the output was of a disyllabic form, either syllable could be retained as the second syllable, reflecting either back-clipping (when the final syllable was omitted) or medial syllable deletion as in the 4–1 category (when the second syllable was omitted). Given that half of the words in the 3–1 target category had secondary stress on the final syllable and half did not, it is possible that similar rates of omission of the second and third syllables reflect different reduction strategies for those words with secondary stress and those without. Further analysis of syllable omissions for the 3–1 category is necessary to confirm the role of secondary stress in the patterns of reductions for these words.

The findings regarding syllable omissions from disyllabic and trisyllabic words are consistent with those found in studies on children's reductions that were discussed above (e.g., Allen & Hawkins, 1980; Gerken, 1994a; Klein, 1981). Adults did not show a tendency for more omissions of the weak initial syllable for the 4–2 category words as children do (Gerken, 1994a; Kehoe & Stoel-Gammon, 1997b; Paradis, 2001), however their omissions from the 4–1 and 4–3 categories show some similarities to children's productions. Kehoe found that when children reduced $S_1w_1s_2w_2$ and $s_1w_1S_2w_2$ words to three syllables, they omitted the unstressed second syllable similarly to what we found with some of the adults' responses (e.g., *alligator* ~ [æ̀lgédə]) and *avocado* ~ [ɑ̀kádo]. When children in her study reduced these same words to two syllables, their reductions took the form of either S_2w_2 or S_1S_2. The former pattern reflects the right edge bias that is exhibited more strongly in children than adults. The latter pattern in children was not seen in the adults in this study, however it perhaps reflects a bias for inclusion of both primary and secondary stressed syllables by the children. Any comparison to adults' responses should be made tentatively, however, because of the small number of four-syllable words used as stimuli in that study, and the variability that was evident across the small number of participants (between six and 11 in each age group).

Finally, it may be the case that some of the syllable omissions reported were brought about by certain segmental patterns in the target. It is the case that certain segmental patterns trigger more syllable omissions than others, as has been shown in children (Carter, 2000; Kehoe, 1999/2000) as well as in adults (Zwicky, 1972). A brief investigation of the responses of individual participants in our study revealed some interactions between segments and syllable omissions. For example, one participant often formed reductions that contained the onset of the initial syllable and rhyme of the final syllable as in [fíg] for *fatígue* or [dít] for *deléte*. Another participant seemed to have a preference for heavy monosyllabic outputs that sometimes was more of an overriding factor than stress in the reduced forms as in [ǽnt] for *gíant* or [kǽf] for *càfé*. However, further research is necessary to examine more fully the role of segmental patterns on adult word truncations.

In addition to the variation found in responses across the different target categories, there was also variation across the participants in this study. In particular, there were

four participants who reduced more than 90% of all of the targets to either a monosyllabic foot or a disyllabic trochaic foot. At the other extreme, there were three participants who produced well-formed prosodic feet as outputs on less than 75% of the trials. These results reveal that different participants had different strategies for performing the task.

Even within a given syllable and stress pattern, data were subject to variation across participants. Some participants showed systematic strategies in their responses, such as always preserving the initial or stressed syllable, or producing a well-formed foot more often than any other prosodic pattern, while other participants randomly reduced words with no apparent strategies. In particular, at least one participant preserved the initial syllable in more than 90% of their responses for the 2–1, 3–1, 3–3, and 4–2 target categories. Similarly, at least one participant preserved the stressed syllable in more than 90% of their responses for the 2–1, 3–1, 3–2, 4–2, and 4–3 target categories. In all of the categories except 4–2, at least one participant produced exclusively well-formed prosodic feet as output responses. Meanwhile, one participant produced 25% monosyllabic feet, 35% disyllabic trochaic feet, and 40% *Other* output patterns for the 3–2 target category, and others omitted the initial, final, or stressed syllables 50% of the time in a given target category, revealing no apparent strategy for reducing words of that syllable number and stress pattern.

Despite this variability in individual reduction strategies and in the overall responses of the participants as a group, we can still draw several conclusions about the implications for these results with respect to adult language processing. In particular, the predominance of prosodically well-formed reduction responses suggests that adults are sensitive to the prosodic structure of and the statistical frequency of monosyllabic and disyllabic trochaic content words in English. The preference for back-clipping in English word formation was supported by our results, which revealed a preference for maintaining initial syllables, but no preference for maintaining final syllables. These results also support the previous evidence in language processing that adults have a left edge bias in lexical access and word recognition. Kreidler (1979) noted that prominent parts of the word are often preserved in reduced forms and primary stressed syllables were maintained more often than deleted in the present study as well. This finding supports the claim made by Cutler and others (Cutler, 1990; Mattys, 1997) that stress plays an important role in adult language processing. In addition, our results also suggest that syllables bearing secondary stress are more prominent than syllables bearing no stress and that there might also be a preference for maintaining syllables with secondary stress in reduced forms. Further study and analysis of the effects of secondary stress is required to fully understand the relationship between the three levels of stress in English and language processing.

Overall, the findings from this study indicate that adult participants in an on-line reduction task behave similarly to other adults, and to children, when truncating words. The tendency to reduce words to well-formed prosodic units and to preserve the primary stressed syllable and other salient syllables is pervasive across both of these populations, and suggests a common language production (or retrieval and storage) mechanism. However, the difference in word-initial syllable preservation (adults) and word-final syllable preservation (children), as well as some of the individual reduction patterns,

suggests that there is a developmental shift in the important elements of the processing mechanism, for example in the varying importance children and adults place on particular word edges.

The idea of developmental differences in an otherwise similar language processing system has been promoted by others as well who have studied production errors in children's and adults' speech (Aitchison, 1972; Aitchison & Straf, 1981; Stemberger, 1989; Wijnen, 1992). Aitchison and colleagues found that children and adults make use of the same salient phonological features (number of syllables, stress pattern, initial consonant, final consonant, and stressed vowel) but place different importance on those salient features (e.g., adults gave a higher priority to the preservation of initial consonants than children, and children gave a higher priority to the preservation of the stressed vowel or the number of syllables in a word). Among their suggested reasons for the dissimilarities, they note that children may pay more attention to perceptually salient aspects of words, such as rhythm, the stressed vowel, and the end of the word when learning new words. Adults on the other hand show a greater familiarity with the written word and with the use of dictionaries and thus may place greater importance on the left edge of words. Finally, as children grow up and gain larger vocabularies, there is a necessity for a more efficient system of lexical storage and retrieval that more closely resembles the adult model.

Evidence for a common processing mechanism among adults and children can even be extended to certain clinical populations, such as children with Specific Language Impairment and adults with acquired aphasia. Individuals in these populations also exhibit similar word reduction behavior, omitting certain unstressed syllables while maintaining perceptually salient syllables and well-formed prosodic patterns (Blumstein, 1973; Chiat & Hirson, 1987; Leonard, 1998; Nickels & Howard, 1999). These findings suggest that such a processing or production mechanism is robust, and that it perhaps is based on statistical properties of English, universal language properties, perceptual salience, or some combination thereof.

4 Summary and Conclusions

In summary, our initial findings using an explicit word reduction task provide evidence that word length and primary stress position do affect word reduction strategies of adults in somewhat systematic patterns. However, these findings also support the conclusions of previous researchers that the phenomenon of word reduction is a complex one. Just as with children, adults default to a well-formed prosodic foot. This finding suggests that not only are children who are acquiring language affected by statistical frequencies of the input, but that normal adults are also aware of these facts and use them in reduction or abbreviation formation. Adults place importance on the primary stressed syllable and the word-initial syllable, whereas children place emphasis on the primary stressed syllable and the word-final syllable. Therefore, adults and children seem to make use of similar acoustic or perceptual salience properties (stressed syllables and word edges) underlying various tasks in language processing, although there seems to be a shift in word edge bias at some point in time from right (word-final) to left (word-initial). These results indicate the validation of and need for more comprehensive and controlled studies of the factors that shape the phenomenon of word reduction in normal, developing, and even disordered populations.

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Appendix

Stimulus Words

2–1	*3–1*	*3–3*	*4–2*
áxle	álib‟	àdiós	alúminum
clóset	álien	bàssinét	àmphíbian
éxit	álmanàc	bàyonét	anátomy
flóunder	ámazòn	càbarét	anémia
gállop	ártichòke	càvalíer	aquárium
gíant	bálcony	chàndelíer	arístocràt
húnger	cártilage	clàrinét	àrtíllery
lántèrn	córridòr	dèbonáir	àuxíliary
máple	cránium	Hàlloweén	conglómerate
méthàne	gálaxy	kàngeróo	conspícuous
móròn	húrricàne	màsqueráde	currículum
núgget	íod‟ne	nèctaríne	eváporàte
róbin	óbstacle	òpportúne	‘nfátuàte
róster	pórcelain	pòtpourrí	península
sérgeant	pórcup‘ne	pròmenáde	petróleum
spíder	récipe	sèrenáde	potássium
stérile	ródeò	s‘lhouétte	precípitàte
tíger	Scórpiò	sòuvenír	predícament
trámple	símile	tàllyhó	pròcrástinàte
tríumph	spátula	tàngeríne	rh‘nóceros

2–2	*3–2*	*4–1*	*4–3*
adápt	abándon	álimòny	ànesthésia
adjúst	abúndant	álligàtor	àrmadíllo
astóund	àlfálfa	ántibòdy	àvocádo
bòmbárd	ànténna	áppet‘zer	cèrebéllum
càfé	bazóoka	cápillàry	cònstellátion
commúte	bikíni	cárburètor	d‘abétes
complý	còyóte	cáterp‘llar	dèsperádo
condémn	diplóma	cáuliflòwer	ènchiláda
contémpt	disáster	cémetèry	èpidémic
decláre	èmbézzle	córonàry	hàciénda
deléte	èmbróider	dándel‘on	‘ncogníto
fatígue	enámel	dórmitòry	‘nfluénza
gazélle	mànháttan	épilèpsy	màcaróni
guitár	màrtíni	hélicòpter	mànufácture
hurráh	màscára	híeràrchy	mèmoráندum
kazóo	mùséum	mélanchòly	pànoráma
pàstél	pajámas	mórtuàry	pàranóia
tòupée	potáto	páratròoper	pènicíllin
tròmbóne	tobóggan	sálamànder	ràvióli
vàccíne	tomáto	tábernàcle	tàpióca