Journal of Speech and Hearing Research, COWAN ET AL., Volume 25, 48-53, March 1982

A FLUENT BACKWARD TALKER

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This report documents the ability of a man to reverse the order of segments within words, so quickly that the simultaneous translation of forward speech into reversed speech was possible. Transcriptions of recorded backward speech and several processing tasks were used to clarify this man's profile of unusual linguistic skills. Analyses of the backward speech showed evidence of sensitivity to both phonemic and orthographic representations of the utterances.

We report here on the ability of a 31-year-old man (A. L.) to speak backward or translate newly-encountered spoken words or sentences into backward speech fluently, without the use of visual materials. Forms of "talking backward" have long been known to exist as secret play languages of childhood (Chrisman, 1893; Conklin, 1956; Sherzer, 1970) and as jargons among members of certain subcultures (Camden, 1901, pp. 347-357; Guiraud, 1956; Monod, 1968). These forms belong to a large class of play languages involving the rearrangement of linguistic units (Conklin, 1959; Haas, 1957; Kirshenblatt-Gimblett, 1976; Laycock, 1972). However, A. L.'s surprising speed and facility with backward speech provides an unusual opportunity for the appraisal of human linguistic capacity. Furthermore, A. L.'s manner of speech reversal may offer evidence for the psychological reality of linguistic units.

One reason for our interest in this fluent backward talker is that his facility for rapid reversal of speech patterns uses units of speech analysis that are readily accessed and manipulated. He could not rely totally on a reversal of orthographic (alphabetic) spelling of an utterance, because English has a relatively poor letter-to-sound conversion (compared to a language like Finnish, which is highly phonetic in its spelling), and because he was able to utter backwards sequences that depart from orthographic conventions of the English language. We sought to determine if A. L.'s backward speech reflected (a) a fast phonetic or phonemic segmentation of an utterance to be reversed, or (b) a stable auditory "mirror image" of an utterance to be reversed.

Linguists commonly assume that speech is composed of *phonemes,* which Ladefoged (1975) defined as the "smallest segments of sound that can be distinguished by their contrast within words" (p. 23). Ladefoged went on to state that phonemes "are the abstract units that form the basis for writing down a language systematically and unambiguously" (pp. 23-24). Thus, a phonemic transcription of the word *earn* should indicate that the *ear-* portion of the word is pronounced not as the word *ear* but rather as the vowel in *burn.* The word *earn* is spelled with four orthographic units, but its phonemic transcription has only two elements, the vowel /ɝ/ and the consonant /n/. Similarly, the word *daughter* is spelled with eight orthographic units but is phonemically transcribed with only half as many elements: / d ɑ ɾ ɚ /.

Part of the challenge that the phoneme represents to psycholinguistic research has been described by Dell and Newman (1980):

> According to modern linguistic theory, the phoneme, or phonetic segment, is one of the major building blocks of language—phonemes are the constituents of words just as words are the constituents of sentences. The role of the phoneme in speech perception, however, is not so clear-cut. While some theorists hold that the construction of a phonetic or phonological representation is a basic process in the perception of fluent speech, others (e.g., Warren, 1976; Klatt, 1980) claim that the phoneme is largely an unnecessary construct. It is certainly true that the naive listener is usually unaware of the phonemic nature of speech. For him or her, speech contains words and ideas, not phonemes. (p. 608)

METHOD

We recorded an impromptu backward monologue and A. L.'s backward translations of our spoken words, sentences, and passages. Detailed analyses were carried out with blind phonemic transcriptions by one author (verified by a second author) of about 250 words and several multisentence passages. In addition, spectrograms were made of some samples to examine acoustic-phonetic details of the backward speech (Figure 1) and to compare speaking rates of A. L.'s forward and backward speech (Figure 2). Other details of the procedure, such as tests

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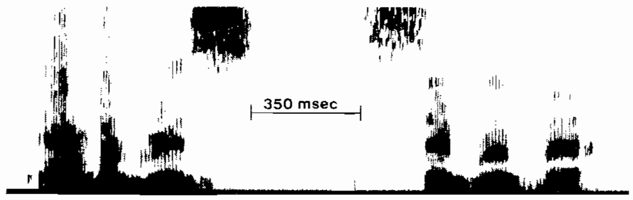

FIGURE 1. A spectrogram of the word *ambergris* spoken by an experimenter (left) and A. L.'s backward translation /sɪrgrəbmæ/ (right).

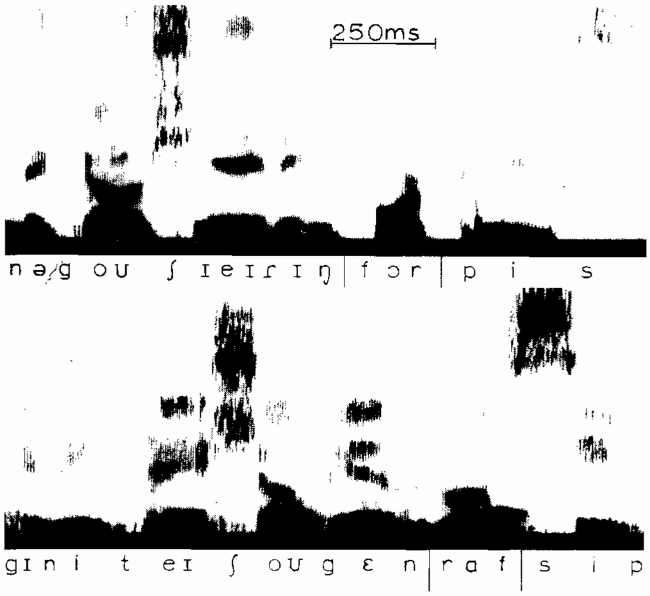

FIGURE 2. Labeled spectrograms of the phrase *negotiating for peace* in A. L.'s forward, or normal, speech (top) and his backward translation (bottom).

of A. L.'s perceptual and mnemonic abilities, are reported as the results are presented.

RESULTS

The results revealed that A. L. always reversed speech by maintaining the original word order but reversing the order of segments within each word (as opposed to each phrase or each morpheme). An example of A. L.'s translation is the phrase *negotiating for peace,* reversed as /gɪnɪteɪʃougɛn rɑf sip/ (shown spectrographically in Figure 2). If the phrase had served as a unit to be reversed, the resulting reversal might have been /sip rɑf gɪniteɪʃougɛn/ (i.e., the words would have appeared in reverse order). On the other hand, if morphemes had served as units to be reversed, the word *negotiating* would have appeared as /teɪʃougɛngəni/ (i.e., the morphemes *negotiat* and *ing* would have been reversed separately but would have remained in the original order). Instead, words were reversed as units. Thus, all suffixes (19 examples) were moved to the beginning of the reversed word—that is, before the root—and all prefixes (4 examples) were moved to the end—that is, after the root.

The order of phonemes or phonetic segments was reversed within words, rather than the order of syllables or subphonemic elements. The error rate was 7% when words were considered accurate only if they contained the correct phonemes in the reverse order. If the order of syllables had been reversed, the word *negotiating* (ne-go-ti-at-ing) should have appeared as /ɪŋeɪtʃɪgoʊnɛ/. On the other hand, if the reversal were an acoustic mirror image, or a reversal that respected subphonemic elements, then the diphthongs /ɔɪ/, /aʊ/, and /aɪ/ would have been reversed. However, these diphthongs were always left intact in the reversed speech. Similarly, the affricates /dʒ/ and /tʃ/ (phonemes consisting of two segments, stop + fricative) were never reversed. Thus, the word *join* /dʒɔɪn/, containing the diphthong /ɔɪ/ and the affricate /dʒ/, was reversed as /nɔɪdʒ/. In contrast, a reversal based on acoustic mirror image or subphonemic elements would have been /nɪɔʒd/. There were no exceptions to this mode of reversal in the data, which included 11 examples of the diphthong /aɪ/, represented orthographically by the letters *i, eye, y,* and *uy;* 10 examples each of the diphthongs /ɔɪ/, and /aʊ/, represented orthographically by *oi, oy, ou,* and *ow;* and 14 affricates, represented orthographically by *ch, ct, j, dg,* and *g.*

The use of phonemes as units is especially interesting inasmuch as A. L. had received no formal linguistic training at the time of testing. The ability of our linguistically untrained subject to reverse the order of phonemes suggests that phonemes may be "psychologically real" for him. Similar arguments for the psychological reality of linguistic units were made by Sherzer (1970) with reference to the game of talking backward played by Cuna children of Panama (also see Halle, 1962). Jaeger (1980), using standard classical conditioning and concept-formation paradigms, reported that her subjects made phoneme-like responses. The present work strengthens these arguments by demonstrating that phonemes tended to remain intact in the linguistic transformation that A. L. developed himself and could apply fluently to almost any English word.

Speed of Reversal

Backward translations of sentences and passages typically lagged behind the forward model by two to five words, and often were emitted during the silent pauses between phrases. Recordings of A. L. translating the Rainbow Passage and four simple sentences were analyzed on a multichannel oscillograph. A. L. began and ended each passage .7–1.8 sec behind the forward model. These and other passages were phonemically accurate except for occasional intrusions from the forward model. If requested, A. L. was also able to delay his response until the end of a sentence.

A. L. also reversed words spoken in isolation very rapidly and with a speaking rate that essentially matched his forward productions (Figure 2). Response times were analyzed by digitally storing and measuring waveforms as described by Gillman, Wilson, Hirsch, and Morse (1975). For 56 words with <4 phonemes each, the mean time between the end of the forward model and the onset of the reversal was 521.8 msec; for 50 words with 4 phonemes each, $\overline{X}$ = 521.1 msec; and for 67 words with 5–11 phonemes each, $\overline{X}$ = 439.9 msec, with response times decreasing with increased phonemic length. The differences between mean response times to words with 5–11 phonemes versus words with 4 phonemes and versus words with <4 phonemes were significant [$F(1, 170) = 9.21$ and 8.43, p's $< .005$]. These effects of phoneme length may be due to the greater processing time available with longer words.

Although these results demonstrate that A. L. reverses speech fluently, they do not provide an estimate of the duration of the reversal process. To provide this estimate, voice reaction times were recorded as A. L. (a) named objects appearing in picture slides, and (b) read slides with the corresponding written words. Two trials were run with each slide: one with A. L.'s response forward and one with his response reversed. After a familiarization session in which the desired names for each object were made clear, two sets of 34 slides were presented with the test apparatus described by Massaro, Jones, Lipscomb, and Scholz (1978). Each set of slides consisted of 17 pictures and 17 words. Tokens that occurred in *picture* form (e.g., of a tomato) within set 1 corresponded to the same tokens in *word* form (e.g., the word *tomato*) within set 2, and vice versa. Both sets of 34 slides were presented twice, once with forward and once with backward verbal responses required. The four sessions were presented in the following order: set 1–backward, set 2–forward, set 1–forward, and set 2–backward. Mean response times for words and pictures were 571.25 and 856.25 msec, respectively [$F(1, 33) = 62.27$, $p < .001$].[1] Furthermore, it took an average of 624.12 msec to respond to a slide with forward speech as compared to 803.38 msec to respond to the same slide with backward speech [$F(1, 33) = 70.22$, $p < .001$]. Thus, the word reversal process added an average of 179.26 msec to A. L.'s response time. There was only a marginal interaction between presentation and response modes, with mean added times for speech reversal of 223.26 msec for pictures and only 135.26 msec for written words [$F(1, 33) = 3.79$, $p < 0.1$].

Allophonic Variation

An additional fact suggesting that phonemes were the units of reversal is that A. L. produced reversed words with allophonic changes from the forward model. A. L. made no apparent effort to control the phonetic realization of each phoneme, that is, he usually produced representations that were easy for an English speaker to pronounce within their specific contexts.

[1]A. L. was instructed to name objects at a normal pace, rather than as quickly as possible. However, his response times are comparable to those observed by Massaro et al.

Violations of English Phonology

A. L. did produce unusual pronunciations when they were required phonemically (26 examples). Specifically, the reversed order of phonemes often violated English phoneme sequencing constraints. For example, the word *bold* was reversed as /dlob/, in which the initial stop-liquid combination is illegal in English. Illegal stop-fricative (e.g., word-initial /ts/), stop-nasal (e.g., word-initial /tn/), fricative-liquid (e.g., word-initial /sr/), and nasal-fricative (e.g., word-initial /mz/) combinations also were produced. On the other hand, A. L. never violated English rules by producing a velar nasal in initial position. For example *ring* (/rɪŋ/) was reversed as /gənɪr rather than /ŋɪr/. Thus, phoneme sequencing constraints had a limited influence on A. L.'s backward speech.

Some examples of reversals that violate English sequencing constraints follow. The first eight examples illustrate violation of sequencing constraints on initial consonant clusters, and the final four examples illustrate reversals in which a phonetic segment appears illegally in utterance-final position.

Word	A. L.'s reversal
bold	/dlob/
burn	/nrʌb/
content	/tnɛtnɑk/
dollars	/srɔlɑd/
honest	/tsɛna/
must	/tsʌm/
project	/tkɛdʒarp/
spasm	/mzæps/
ambergris	/sɪrgrɛbmæ/
wheelbarrow	/oræbliju/
with	/θiu/
woman	/næmoʊ/

Phonology versus Orthography

Several facts indicate that A. L. reversed words by a process that is both phonemic and orthographic in nature. First, a phonemic, rather than orthographic, sensitivity was apparent in the fact that A. L. never pronounced the silent letters *s* as in *island, b* as in *bomb, u* as in *plague*, and *gh* as in *weigh*. However, final silent *e* sometimes was pronounced, but only in phonetic combination with another sound (such as /ɛlkaɪs/ for *cycle*), making it uncertain whether the *e* itself was pronounced or whether A. L. simply inserted a word-initial /ɛ/ to make combinations such as /lk/ pronounceable.

A. L. also preserved sound distinctions between words with the same letter combinations (same orthographic rendering). For example, the letters *ct* may represent stop + fricative (e.g., *dictionary*) or stop + affricate (e.g., *lecture*), and A. L. reversed them accordingly. In addition, he reversed homographs differently, e.g., the name *Begin* and the verb *begin* were reversed as /nɪgeb/ and /nɪgib/, respectively. Furthermore, he was able to reverse foreign words (e.g., the Hebrew *mishpacha* = family) and nonsense words (e.g., *straylagrump*), for which English written forms are nonstandard.

On the other hand, orthography sometimes influenced pronunciations. The phoneme pair /ju/ was reversed when represented by the letters *you* as in *youth*, but was treated as a single unit and not reversed when represented by the letter *u* as in *use*. The letter *x* representing /ks/ was pronounced as /ks/ in some reversed words but as /sk/ in others. The word *judge* was reversed as /dʒdʌdʒ/ rather than /dʒʌdʒ/. The initial vowel in *automobile* (/ɑ/) was pronounced as /uʌ/ in the reversal.

Occasionally, A. L.'s reversals violated the phonetic sequencing constraints of English but still had an orthographic bias inconsistent with a truly phonemic reversal. For example, the word *bank* was reversed as /knæb/ rather than /kŋæb/; *burn* was reversed as /nrʌb/ rather than /nɝb/ (although the latter does not violate English sequencing constraints); and *dollars* was reversed as /srɔlɑd/ rather than /zrɔlɑd/. Thus, A. L.'s segmentation of words into phoneme-sized units was not perfect: orthographic contamination was clearly evident. Other examples of orthographic sensitivity are given below. Because A. L. preserved diphthongs in his reversals, the elements of diphthongs are transcribed with a bar or overline.

Word	A. L.'s reversal	True phonemic reversal
allowed	/dəa͞ʊlə/	/da͞ʊlə/
gathering	/gɪniræðæg/	/ŋɪrəðæg/
had	/da/	/dæ^{h}/
hearse	/srɛ/	/sɝ^{h}/
king	/gɪnik/	/ŋɪk/
number	/rɛbmʌn/	/ɚbmʌn/
once	/sno/	/snʌw/
personal	/lɑnəsrɛp/	/lənəsɝp/
pounds	/dzɪna͞ʊp/	/zdna͞ʊp/

Intonation

A. L. produced a falling, English-like intonation contour across each "backward" declarative sentence (in which words remained in the original order). Interrogative intonation also was maintained in backward questions. A. L. tended to preserve the original, unreversed stress patterns within words. This can be seen most clearly with sentences in which contrasting test words were included. For example, accurate forward stress was maintained in the word pairs *'present* (adj.) versus *pre'sent (verb)*, *'permit* (noun) versus *per'mit* (verb), and *'Begin* (name) versus *be'gin* (verb). On the other hand, word stress was greatly altered in a few examples, e.g., *encyclopedia* (/ɛnsaɪklo'pidiə/) was reversed as /ai'dipolkaɪsnɛ/. Additionally, stress was often delayed until the first consonant, for example, *dictionary* (/'dɪkʃənɛri/) was reversed as /i'rænɪʃkɪd/. Typically, though, forward stress and intonation were superimposed on reversed phonemic representations. These results are evidence of the separability of segmental and prosodic aspects of speech. This separability also is observed in sequencing errors (slips of the tongue) in normal speech (Fromkin, 1971).

When played backward, A. L.'s reversed words sounded like distorted versions of the original model. Thirteen English-speaking volunteers listened to 30 of A. L.'s reversed words (with 3–8 phonemes) played backward with a 2-track, TEAC 3300s tape deck, a high-quality amplifier, and an AR-4xa speaker. Six subjects were given a randomized written list of the words, whereas seven subjects were given no aids to identification. These groups identified 70% and 15% of the words correctly, respectively. Long words were identified correctly more often than shorter words, and low identifiability was due largely to interword confusions, for example, *play* versus *plague*. The low percentage of identifiable words in the absence of a response list occurred also because intonation, affricates, and diphthongs were reversed when the tape was played backward.

Perceptual Ability

A. L.'s extraordinary ability includes *perception* as well as production: He was able to identify words spoken backward by an experimenter (roughly in A. L.'s own style) far better than control subjects. Backward-spoken versions of 19 two- to five-syllable words that A. L. had not received as stimuli were played to A. L. and to four volunteers who had 30 min prior exposure to A. L.'s backward speech. A. L. identified 11 stimuli correctly, in comparison to the volunteers' correct identification of 4, 3, 2, and 2 words, respectively, even though A. L. listened to the stimuli only once whereas the control subjects heard the stimulus series three times.

Mnemònic Abilities

Almost anyone can learn to reverse very short words quickly. The most unusual aspect of A. L.'s backward talking skill is his ability to reverse longer words quickly as well (e.g., *university, evolutionary,* and *encyclopedia*). This ability to reverse long words seems to require an ability to keep a string of phonemes (or alternatively, an acoustic or phonetic trace) in a short-term storage long enough to plan an articulatory scheme based on the reversed phoneme order. Limitations in A. L.'s ability were observed, however: He was unable to reverse fluently some words with 10 or more phonemes (e.g., *implementation, philanthropy,* and *interdependency*). These words may surpass A. L.'s short-term memory capacity or speed of articulatory planning.

In order to compare A. L.'s short-term memory capacity to that of normal adults, the digit span portion of the WAIS (Wechsler, 1955) was administered twice on separate days. An interesting aspect of this task is that the forward and backward subtests of the digit span may allow an assessment of different memory skills. Brain-damaged patients with visuospatial deficits show selective impairment of backward digit span (Costa, 1975; Sterne, 1969; Weinberg, Diller, Gerstman, & Schulman, 1972). Thus, the backward digit span seems to rely on the ability to visualize the string of digits. In contrast, forward digit span may rely more heavily upon an auditorily based memory. A. L. successfully repeated 8-digit strings forward and 5-digit strings backward on both occasions. These forward and backward digit spans are approximately 2 and 1 *SD*s, respectively, above published norms (Costa, 1975; Sterne, 1969) of about 6 digits forward and 4 digits backward. Thus, A. L. has a good but not truly extraordinary memory and does not show a selective advantage for the backward repetition of digits.

Another backward talker was studied by Coltheart and Glick (1974). These experimenters did not describe the backward speech of their subject in detail,[2] but investigated the characteristics of her visual memory. For example, their backward talker was able to *spell sentences backward* (starting with the last word) much more quickly and accurately than control subjects. We administered this task to A. L. with the same stimuli, and found that his performance was comparable to that of the other backward talker. The mean time to sentence completion was 20.95 sec for A. L. and 27.65 sec for Coltheart and Glick's backward talker, as compared to 61.70 sec for the average control subject. Furthermore, A. L. and the other backward talker misspelled 2 and 1 words, respectively, in comparison to a mean of 9.0 words for control subjects. (On the other hand, A. L. and the control subjects sometimes omitted very short words, but the other backward talker did not). The similarity between the two backward talkers in backward spelling suggests that similar skills may underlie speaking and spelling backward. However, A. L. was unable to spell some long words backward even though he could reverse them in spoken form. Thus, A. L. does not seem to require a complete reversed orthographic representation to say a word backward.

It is interesting that A. L. performed extraordinarily well on backward talking and spelling tasks and nonetheless performed only in the high-normal range on the backward digit span tasks. We hypothesized that the differences between these types of ability might be related to the phonogramic versus numerical units to be reversed. To test this possibility, we constructed a letter span task as a linguistic analogue to the digit span task. Letter strings were chosen randomly from the alphabet (without replacement within a trial) and were administered to A. L. and to 16 control subjects with a procedure otherwise identical to that used in the forward and backward digit span tasks. As in the digit span task, A. L.'s forward and backward letter spans (7 and 5) were about 2 and 1 *SD*s, respectively, above the control values (forward: $\overline{X} = 5.75$, $SD = .68$; backward: $\overline{X} = 4.06$, $SD = 1.06$). Thus, the distinguishing feature of tasks on which A. L. performs unusually well does not seem to be their phonogramic as opposed to numerical character. Moreover, control subjects with backward letter spans as long ($n = 3$) or longer ($n = 2$) than A. L.'s backward span of 5 were unable to reverse long words when instructed to do so.

[2]Unlike A. L., the other backward talker apparently reversed words primarily according to their orthographic representation (Coltheart, Note 1).

Another possible explanation of the discrepancy between A. L.'s (extraordinary) level of performance on backward speaking and spelling as opposed to his (high normal) performance on backward digit and letter span is that these types of tasks may draw upon different processing abilities. In digit and letter string reversal, one must hold the items in short-term memory while reversing their sequence. In contrast, backward speaking and spelling are tasks that permit the subject to recover much of the necessary sequential information from long-term memory. A. L. may excel in the retrieval or use of this type of information. Perhaps through practice talking backward, he has acquired a repertoire of known reversed sequences (e.g., phoneme clusters or syllables) that can be used in combination to quickly reverse a new word on the first attempt. This learned information may also be of use in backward spelling even though it was not acquired for that purpose.

Personal History of A. L.'s Ability

A. L. is an intelligent man with no apparent physical, mental, or emotional abnormalities, employed as a professor of philosophy. His first recollection of talking backward is at the age of 12, in 1959, after having watched televised conferences with Russian-English simultaneous translation. He was unable to speak Russian but found that he could mimic Russian by converting each English word into its backward form. On the other hand, a friend from his 4th-grade class maintains that A. L. talked backward then as well, although A. L. apparently did not *converse* with friends using backward speech. Thus, the origin of A. L.'s ability and the amount that he practiced is unclear.

CONCLUSIONS

The results of this study are of two varieties. First, A. L.'s reversed speech output provides new evidence that a linguistically untrained speaker can intuitively analyze speech into separable, manipulable units at the lexical and phonemic levels. Second, A. L.'s unusual ability to reverse long words and to spell backward quickly, in conjunction with a very good but *not* extraordinary ability to reverse digit and letter strings, suggests that he may excel in the retrieval of sequential linguistic information from long-term memory.

The significance of studies of exceptional mental abilities is that they help to define the boundaries of the human cognitive capacity. In addition to the employment of presumably normal abilities (e.g., an intuitive knowledge of lexical and phonemic units) in a novel way, the ability to speak backward may require psychological processing skills (e.g., memory or manipulation of linguistic units) of substantial practical value. The present documentation of A. L.'s coherent "system" of backward speech could provide a vehicle for future investigations of the trainability of those psychological skills.

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Received October 2, 1980
Accepted December 19, 1980

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Reprinted from *Journal of Speech and Hearing Research*
March 1982, Vol. 25, No. 1