THE TONGUE-TWISTER EFFECT: SUBVOCAL ARTICULATION IN SILENT READING

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ABSTRACT

An experiment was conducted to determine whether there is subvocal articulation in reading. College students were asked to read silently or aloud difficult tongue twisters, easy tongue twisters and normal sentences which were matched for syntactic complexity, number of syllables and stress pattern. The time it took for the subjects to finish reading each sentence was measured. Results showed reliable reading time differences among all types of sentences, but not between modes of reading. In particular, whether subjects read the sentences aloud or silently, reading times for difficult tongue twisters were longer than those for easy tongue twisters which were also longer than those for normal sentences. The results, which indicate articulatory effects both for silent and oral reading, were discussed in relation to theories about subvocal articulation in reading.

Reading is a very important skill which pervades our daily activities. When we ride or drive towards school or work, we encounter traffic signs and directions which we need to read. In their educational activities, students constantly course over books, notes, writings on the blackboard and other varied forms of reading materials. In their regular work schedule, office workers, routinely go through stacks of files, memos, records, and other documents. To keep abreast with current information and issues, people read newspapers, journals, and other periodicals. Even for entertainment or relaxation, we read novels, stories, comic books, and so on. Reading has become an unescapable task in our literate society.

When we read, there often seems to be an inner voice reading along with us. This inner voice seems more apparent when reading silently. Psychologists have come to refer to this phenomenon as subvocal articulation. Subvocal articulation was defined by Locke (1971) as the covert oral activity which usually accompanies reading. This activity is equivalent to talking to oneself and listening to what one says, however, the talking occurs without actual vocalization, hence, the term subvocal. Subvocal articulation is said to be related to oral reading which is usually stressed in the early stages of learning how to read. Teachers encouraged oral reading at this stage in order to monitor the students' performance. However, as students become skilled in reading, the oral component in their silent reading seems to remain. Therefore, the reading skill is initially acquired as an oral process and it never quite loses its vestigial speech basis, even when speech is no longer relevant or useful (Haber & Haber, 1982; Kavenagh & Mattingly, 1972; Kleiman, 1975; Levy, 1978).

Several studies have suggested the presence of subvocal articulation in adult reading.

Eriksen, Pollack and Montague (1970) showed that words with three syllables had significantly longer latency in voicing as compared to one or two-syllable words. This shows that irrelevant phonological features of stimuli affect visual performance. Other studies (Locke, 1971; McGuigan, 1970; Hardyck & Petrinovich, 1970) measured speech muscle activity by securing electromyographic (EMG) surface electrodes to the chin and interior surface of the lower lip. It was found that EMG readings increased significantly from resting conditions when children and adults read silently, indicating the presence of subvocal articulation. Furthermore, there was less speech muscle activity during the reading of easy text than during the reading of hard text (Hardyck & Petrinovich, 1970).

Haber and Haber (1982) and Ayres (1984) conducted further experiments to determine whether there is subvocal articulation during silent and oral reading. In these studies, subjects were given easy and difficult sentences to read either silently or aloud. The difficult sentences were tongue twisters that contained words with the same initial phonemes. The easy sentences were normal sentences used in daily conversation which contained no similar initial phonemes. The researches showed that subjects took longer to read the difficult sentences compared to normal sentences regardless of whether these sentences were read silently or orally. Hence, they found articulatory effects in both silent and oral reading, even if, intuitively, articulation should not affect silent reading. These results strongly support the view that subvocal articulation is always present in reading and that is cannot be suppresed.

This experiment is a replication of the Haber and Haber (1982) study using a finer test of the subvocal articulation hypothesis. Two variables were manipulated in this study: the mode of reading and the kinds of sentence. Similar to the Haber and Haber study, the two modes of reading used were silent and oral reading. Oral reading involved reading the sentence aloud which would be necessarily be affected by articulatory and phonetic features of the sentence. Silent reading involved reading the sentence to oneself without moving one's lips, which might not necessarily be affected by the same factors. This variable was, therefore, studied to determine if subvocal articulation in present particularly in silent reading. If there is subvocal articulation, the mode of reading would not affect the time it takes to read the different kinds of sentences (Eriksen, Pollack, &Montague, 1970; Landauer, 1962).[1]

Haber and Haber (1982) used two kinds of sentences: tongue twisters and control sentences. The assumption was that tongue twisters, compared to normal sentences, are more difficult to articulate. Differences in performance between the two types of sentences would indicate the presence of articulatory effects. In this experiment, a finer distinction is made for sentence difficulty by further differentiating tongue-twister sentences into easy tongue twisters and difficult tongue twisters. We made a distinction between easy and difficult tongue twisters by using different sets of consonant/consonant clusters as initial phonemes. The consonant occurences in the easy tongue twisters are more common and are earlier acquired relative to the consonant occurences in the difficult tongue twisters. An easy tongue twister was defined as a sentence in which one of the following initial phonemes was used repeatedly: /n/, /r/, /s/, /t/, /l/, /d/. These phonemes are the most common consonant occurences in any language (with the possible exception of the click languages in Africa) and are also typically the first sounds acquired by children in any language (Carterette & Jones, 1974; Mines, Hansen, &

[1] There are other factors not related to phonetic or articulatory features that would affect the reading times. One such factor is the syntactic structure which would affect ease of comprehension. This factor was controlled in the study by using equivalent syntactic structures across different types of sentences.

Shoup, 1978; Palermo, 1978; Taylor and Taylor, 1990). A difficult tongue twister was defined as a sentence in which one of the following speech sounds was used repeatedly: /ǰ/, /č/, /š/, /θ/, /s+consonant/. The first four sounds are all voiced fricative phonemes which are the least frequent sounds across all languages (these sounds are actually absent in many languages) and also tend to be acquired late by children in any language. These sounds also tend to be lost in brain damage, suggesting that they require fine coordination of the articulators (Palermo, 1978; Taylor & Taylor 1990). The /s+consonant/ consonant cluster was also used in the difficult tongue twisters because this speech sound is never used as an initial consonant cluster in Filipino. In practice, we commonly hear Filipinos say /Iskirt/ instead of /skirt/ or /Istiker/ instead /stiker/ (sticker). Likewise, when Filipinos adopt an English word with an initial /s+consonant/ cluster into the Filipino language, the English word is modified by adding either /i/ or /ɛ/ before the /s+consonant/ cluster (e.g., "espesyal" and "iskolar") or by dropping the /s/ from the cluster (e.g., "tambay" from "stand-bye"). These observations suggest that Filipinos have a difficult time articulating the /s+consonant/ cluster.

In this experiment, therefore, there are three levels of sentence difficulty in articulation. It was predicted that if the subvocal articulation hypothesis were correct, then subjects should take longer to read the difficult tongue twisters not only compared to the normal sentences but also compared to the easy tongue twisters. Furthermore, subjects should take longer to read the easy tongue twister compared to the normal sentence. Finally, these differences should be found whether the subjects are reading the sentences silently or orally.

Another important modification of the Haber and Haber study was introduced. In their study, subjects read each of the sentences five times. According to Ayres (1984), tongue twisters seem to become harder to articulate with repetition. Repetition of tongue twisters, therefore, results to increases in reading time; in contrast, the necessary reading time for the control sentences decreased with repetition. Thus, according to Ayres, the repetition of sentences could have affected the Haber and Haber results. In this experiment, this confound was avoided by requiring the subjects to read each sentence only once.

In review, this study was intended to provide a finer and better controlled test of the subvocal articulation hypothesis. It was hypothesized that if subvocal articulation is always present in reading, subjects should take longest in reading the difficult tongue twisters followed by the easy tongue twisters and finally by the normal or control sentences. This pattern should be true whether these sentences were read orally or silently. On the other hand, if the subvocal articulation hypothesis were incorrect, the predicted pattern should be observed in oral reading but not in silent reading.

METHOD

Subjects

There were 84 students of the University of the Philippines, Diliman who participated in the study. The subjects were either volunteers or Introductory Psychology students who participated as part of a class requirement.

Materials

Thirty sentences were constructed for use in this experiment: 10 difficult tongue twisters, 10 easy tongue twisters, and 10 control sentences. The same sentences were used in the silent and the oral reading conditions. A difficult tongue twister contained words that began with one of the following initial phonemes: /ǰ/, /č/, /š/, /θ/, /s + consonant/. An easy tongue twister contained words that began with one of the following initial sounds /n/, /r/, /s/, /t/, /l/, /d/. The control sentences contained no word that had the same initial consonant or consonant cluster (see Appendix

for the complete list of sentences used in the experiment).

The different sentences used contained from 11 to 24 syllables. The sentences also differed in the distribution of stresses and their syntactic complexity. Each difficult tongue twister was carefully matched in syntactic structure, in the number of stresses, and in the number of syllables with an easy tongue twister and a control sentence. Consider, for example, the difficult tongue twister: "The third thief throws the things through the thicket thus thwarting them." The number of syllables per word was:

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and the syntactic structure of the sentence contains a noun phrase and two verb phrases. The noun phrase contains an article, a modifier, and a noun. The first verb phrase contains a verb, a noun phrase, and a prepositional phrase; where the noun phrase contains a preposition and a noun phrase. The second verb phrase contains an adverb, a verb, and a pronoun. The corresponding easy tongue twister was "The mean man mends the mats in the malt shop thus marking them." The corresponding control sentence was "Two old men fly the plane through the crevice thus losing them."

The sentences were randomly arranged to form a list of 30 sentences. Four different randomly arranged lists were created from the 30 sentences. A list was randomly assigned to each subject.

The list of words were presented to each subject using an IBM-compatible (XT) computer. The computer was also used to measure the reading times and to record all the reading time data. A microphone was mounted beside the computer, but was not attached to any recorder. The microphone was used to make the subjects think that their speech was being monitored during the experiment (i.e., if the subject was in the oral reading condition, the microphone was supposed to check if she was indeed reading the sentences properly; if the subject was in the silent reading condition, the microphone was supposed to check if she was indeed not producing any sounds while reading.)

Procedures

The subjects were asked to read the instructions on the computer screen. They were told that 30 sentences will be presented on the screen one at a time. Their task was to read each sentence either silently or aloud, depending on their randomly assigned reading mode. They were told to press the "Return" key to make a sentence appear on the screen. As soon as the sentence appeared they were supposed to read the sentence only once and as quickly as possible. As soon as they finish reading the sentence, they were required to press a red marked key which made the sentence disappear from the screen. They repeated this sequence until all 30 sentences were completed.

To help the subjects do the task as quickly as possible, they were told to place their right index finger on the red marked key, and their smallest right finger on the "Return" key. Moreover, the subjects were given four practice sentences before the actual experimental trials.

RESULTS

This experiment was conducted to test subvocal articulation hypothesis. It was predicted that if subvocal articulation is always present in reading, subjects should take longest in reading the difficult tongue twisters followed by the easy tongue twisters and finally by the normal or control sentences. More importantly, this pattern was also predicted to be true whether the sentences were read orally or silently. The mean reading times for each sentence type and reading condition that are summarized in Table 1 suggest that all these predictions were verified.

The means were analyzed using a 2 x 3 ANOVA for mixed factorial designs with reading mode as between group factor and

Table 1. Mean Reading Time in milliseconds (and standard error) as a function of Sentence Type and Mode of Reading

	Mode of Reading	
Sentence Type	Silent	Oral
Difficult tongue twister	5383.90 (363.16)	5453.72 (221.07)
Easy tongue twister	4879.51 (308.59)	5166.96 (198.10)
Control	4631.03 (270.09)	4714.22 (180.98)

sentence type as within group factor. Consistent with the hypotheses, there was a main effect of sentence type, $F(2, 164) = 43.10$, $MSe = 135729.30$, $p<.0001$. The mean reading times for the different types of sentences reflect the predicted pattern; with the subjects taking the longest time to read the difficult tongue twisters and taking the shortest time to read the control sentences.

Also as predicted, there was no reliable main effect of the mode of reading, $F(1, 82) = 0.16$, $MSe = 4241654.9$, $p>.10$. Subjects took just as long to read the sentences silently as they did orally. Most importantly, there was no reliable interaction effect between the mode of reading and type of sentences, $F(2, 165) = 1.15$, $MSe = 135729.30$, $p>.10$. The pattern of differences in the reading times for the different types of sentences was the same, whether the subjects read the sentences aloud or silently. These results of the ANOVA strongly support the subvocal articulation hypothesis.

To have a finer test of this hypothesis, the means for each type of sentence within each mode of reading were compared using the F-contrast for pairwise comparisons. The results show that when reading aloud, subjects took longer to read difficult tongue twisters compared to the control sentences, $F(1, 40) = 11^{\prime\prime}.26$, $MSe = 95603.821$, $p<.0001$. Subjects also took longer to read the easy tongue twisters compared to the control sentence, $F(1, 40) = 4).81$, $MSe = 102969.67$, $p<.0001$. These results replicate Haber and Haber's (1982) findings. Consistent with the finer distinctions made in the hypothesis, subjects also took longer to read the difficult tongue twisters compared to the easy tongue twisters, $F(1, 40) = 17.96$, $MSe = 93888.005$, $p<.0001$.

The same pattern of results was observed when subjects read the sentences silently. Subjects also took longer to read the difficult tongue twisters compared to the control sentences, $F(1, 42) = 19.62$, $MSe = 621075.34$, $p<.0001$. They also took longer to read the easy tongue twisters compared to the control sentences, $F(1, 42) = 3.66$, $MSe = 362677.12$, $p<.0001 = .06$. These results also replicate the Haber and Haber findings. Finally, the subjects also took longer to read the difficult tongue twisters compared to the easy tongue twisters, $F(1,42) = 16.69$, $MSe = 327684.642$, $p<.0002$.

DISCUSSION

The results of this experiment replicate the findings of Haber and Haber (1982) on their study of the tongue twister effect in silent and oral reading. The results of this experiment improve on Haber and Haber's findings by showing a finer difference in reading performance between difficult and easy tongue twisters, both in the silent and oral reading conditions. The performance difference was also demonstrated after a confounding variable (repetition of sentences) was controlled. All these results provide strong support for the hypothesis that there is subvocal articulation while reading silently or orally.

The most striking aspect of the tongue twister effect is that we find the effects of phonological and articulatory factors on silent reading, which need not depend on such fac-

tors. It is reasonable to expect that phonological and articulatory features would affect oral reading. It has been shown that speech production or pronunciation involving repeating the same or similar consonants is awkward and prone to error (Taylor & Taylor, 1990). But intuitively, the same need not be true for silent reading. The results of this and other experiments (see e.g., Daneman and Stainton, 1991) suggest that regardless of the mode of reading, reading involves the same underlying processes. Eriksen, Pollack, and Montague (1970) proposed that the process of encoding in reading is accompanied by subvocal articulation. Information is read out or encoded from a temporary sensory store and is transformed into another form of representation in working memory. This new representation allows the processing of individual words and assembling of words into phrases and sentences (Baddeley & Hitch, 1974; Huey, 1968; Perfetti, 1985; Shankweiler & Crain, 1986).

This explanation would explain why readers have difficulty in reading tongue twisters whether they are read aloud or silently. Whether subjects are reading orally or silently, they are encoding the phonetic features of the words in a temporary store. Since all the content words of tongue twisters begin with the same phoneme or consonant, their representations in the temporary sensory store are similar. This similarity, then results to interference when the readers begin to reprocess the words and obtain more complete word information from memory (McCutchen & Perfetti, 1982).

Consistent with the above explanation, Hanson, Goodell and Perfetti (1991) found that deaf college students experienced the same interference during silent reading of tongue twisters. Although they have access to other ways of processing information, they continue to encode information phonologically. The phonological encoding and processing of stimuli, despite their difficulty provides support for their importance in reading.

The importance of phonological encoding in reading is most evident in the process of acquiring reading skills. Perfetti and Lesgold (1977), for example, suggested that beginning readers who are slow in developing good reading skills may be so primarily because of their difficulties in creating a phonemic code during reading. Hockberg (1976, cited in Baddeley, Logie, & Nimmo-Smith, 1985) also pointed out that fluent reading is always mediated by the creation of a speech articulation program. Several studies reported the occurence of speech muscle activity during silent reading. It was shown that speech muscle activity was greater with difficult as compared to easy text (Hardyck and Petrinovich, 1970). Suppressing that activity, which is possible, reduced subsequent comprehension. Learning then is facilitated by an increase in the amount of vocal activity (Gibson & Levin, 1975; Hardyck & Petrinovich, 1970; Locke, 1971). There seems to be more learning when readers articulate the words they read rather than just being silent. As a consequence, suppressing speech activity results in reduced comprehension. We could even suggest that in practice, subvocal speech should increase as the difficulty of the reading materials increase.

For future research efforts, it might be interesting to look at whether the tongue-twister effect would also be found when reading text in Filipino. (With a similar goal, Zhang & Perfetti, 1993, studied the tongue twister effect in reading Chinese characters; see also Perfetti & Zhang, 1991). It would be worthwhile to study the phenomenon in Filipino not only for the purpose of further generalizing what we know about the role of phonological processes in reading. The Filipino language is considered by some to be somewhat of a tongue twister in itself. We commonly produce and hear sentences with repeated phonemes. One can even have a

complete exchange by simply repeating one phoneme as illustrated in the following:

"Aba, bababa ba?" (Well, is he/she coming down?)

"Bababa." (He/She is coming down.)

"Ah, bababa." (I see, he/she is coming down.)

This characteristic of the Filipino language is very distinct from the English languages. Because of this difference, investigating the phenomenon using the Filipino language might just reveal new aspects of the phonological processes in reading that would not be revealed using the English language.

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APPENDIX

COMPLETE LIST OF SENTENCES USED IN EXPERIMENT

Difficult Tongue Twisters

Slim, sleepy Sloan slugged Slide slinging sleeves at Slatewoods.

Stunning starlet, Stella Stevens, stashed stereos into Steward Sterling Stratford's stately stable.

Jaunty Jones never josteld jolly, jerky judges nor jumbled Joel's jumbo, junky journal.

Smug Smith's small, smashing smile smeared Smitty Smoke's small smudge smoothly.

Cherry Chambers chooses charmly, chiselling and chipping Chandlerson Chappleman's choices.

Snickering Snotty, snipping snared snakes, snagged snapping snails sniffing snow.

Ship-shape Sheila said, "She should sell shimmering sheep-shaped seashells by the seashore."

The sixth, sheer, chic sheikh's sixty-sixth shipped sheep's sick.

Scary scoundrels scorned scores of scrawny, scoffing, scheming, scathing scholars.

The third thief throws the things through the thicket thus thwarting them.

Easy Tongue Twisters

Nine nimble newsmen nabbed knights nibbling nuts near Norway.

Leery Landlow Larry Riley lured Lyra into Ruler Laurie Ralleigh's lowered lorry.

Naughty Nan never knitted knotty nubby nighties nor nibbled Nana's newly kneaded noodles.

Layne Leed's lean little steed led Lester Lee's lead sled sleekly.

Dilton Doily dances daily, damaging and dropping Delaney Dolittle's daisies.

Twittering Tommy, twiddling two toes, teased tesy Tess' twenty tots.

Many men moaned, "Mart must meet masterful, modest Matthew at the market."

The tenth, tall, tense twin's twenty-third tame toad's tied.

Seven siblings saw scores of silent, single, silly, swingy sisters.

The mean man mends the mats in the malt-shop thus marking them.

Control Sentences

Twelve mindless bankers gave winning deals in Frankfurt.

Pretty writer, Mina Santos, writes lyrics for sexy Tessa Lazo's unique songs.

Thoughtful Jan always creates sumptuous chewy brownies and dispensed tasty icy sherbets.

Sue Lim's kind able aide typed Martin Ross' long report neatly.

Lorna Puno meddles often, provoking and testing Marita Concepcion's anger.

Beautiful Clara, showing fine legs, hooked pleasant Mark, stunning him.

Brainy Sam said, "Dan should by expensive, sturdy painttools at the hardware."

The harsh, tough, queer man's carelessly trimmed beard's coarse.

Thrifty farmers bought lots of tiny, healthy, unripe baby seedlings.

Two old men fly the plane through the crevice thus losing them.