Children's prerecall phonetic processing of pictures and printed words*

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Twenty-six second- and third-grade children orally recalled lists of pictures or printed words which contained labial or nonlabial phonemes in their pronunciation. During stimulus presentation and rehearsal, electromyographic (EMG) recordings from the labial area were obtained. Analysis of EMG tracings showed that (1) tracing amplitudes were significantly greater for labial than for nonlabial words; (2) subvocalization was elicited equally by pictures and words; (3) peak amplitudes for words were significantly greater during rehearsal than during presentation; and (4) there were no differences in the recall scores of subvocalizers and nonsubvocalizers. Findings are discussed in relation to phonetic mediation theory and overt phonetic behavior as a form of oral communication.

When man must memorize visual stimuli, he is inclined, where he can, to make implicit phonetic responses (see review in Locke, 1970; Locke & Fehr, 1970a). It appears that his recall may not be exclusively of the original stimuli, but of these covert speech-like responses as well or instead (Conrad, 1963; Wickelgren, 1966; Hintzman, 1967; Locke, 1971a). If stimuli are unlikely to elicit articulatory responses, probably there will be no phonetic mediation (Conrad & Rush, 1965; Blanton & Odom, 1968; Locke & Locke, 1971; Locke, 1971b). Therefore, the degree to which stimuli have the capacity to elicit subvocalization may influence, more or less, the nature of recall.¹

Six-year-old children subvocalize to orthographic stimuli (McGuigan, Keller, & Stanton, 1964), and 4-year-old children subvocalize to pictorial stimuli (Locke & Fehr, 1970b). However, it is not known whether children's covert speech activity is equally elicited by these two stimulus forms, nor is it known whether children's recall of pictures and printed words is equal.² Since experiments must necessarily use language or nonlanguage stimuli, it seems appropriate to assess the degree to which children's subvocal rehearsal is elicited by these stimulus classes. If subvocalization differs for orthographic and pictorial stimuli, different recall patterns, possibly

attributable to varying mediational effects, may result.

Previous work suggests several predictions regarding the degree to which subvocalization may be elicited by language vs nonlanguage stimuli. A grapheme-phoneme hypothesis would describe subvocalization to a printed word as the product of numerous trials (phonics training) in which phonetic (motor/acoustic) responses become associated with the appearance of orthographic characters (as observed in Locke, 1971c). Eventually, the grapheme elicits and is replaced by an articulatory response; the letter "becomes" the sound. A tenable alternate hypothesis predicts that children's strong tendency to label stimuli causes an articulatory artifact to appear whenever children process pictorial stimuli for which they possess labels (as described in Flavell, Friedrichs, & Hoyt, 1970). The printed word as a recognizable but not, in the strictest sense, labelable stimulus would elicit less subvocalization.

SUBJECTS

The Ss were 26 males and females who, in the previous month, had successfully completed second or third grade and whose ability to recognize printed words was at least at a second-grade level.

STIMULI

The stimuli, mounted on 35-mm slides, consisted of 24 nonlabial (e.g., TRAIN, LION) and 24 labial (e.g., BOAT, FLOWER) words and their corresponding pictures, making a total of 96 stimulus items. The words appeared in uppercase sans-serif type (IBM Code 059) and the pictures were black-on-white line drawings. The labial words contained at least one labial phoneme in their pronunciation (/p/, /b/, /m/, /w/, /f/, /v/), and the nonlabial words did not. Experimental stimuli were chosen from all possible picturable and unambiguous words

listed in Britain's second-grade word list (in Fitzgerald, 1951, pp. 56-127). Items were arranged in 24 lists, each containing four slides. Six lists each represented conditions of labial pictures, nonlabial pictures, labial words, and nonlabial words. Each child received a series of 12 lists. All lists were chosen and randomized according to the following criteria: (1) each series contained three lists from each of the four above conditions; (2) no child viewed corresponding picture and word items; (3) children were balanced in pairs—the second child saw the 12 lists that were not viewed by the first child; (4) each list appeared an equal number of times in the experiment; (5) no series had four picture or four word lists in succession; and (6) where three lists occurred successively, both labial conditions were represented.

PROCEDURE

The Ss were tested individually in a quiet, electrically shielded room, seated approximately 10 ft from a slide screen. EMG and sound-recording equipment were in an adjoining room. Two Grass silver chlorided electrodes, 9 mm in diam, were secured with Grass electrode cream and adhesive tape to each S's lower lip and chin, a site which reliably detects labial phoneme subvocalization (Locke & Fehr, 1971a, b). One lead was placed between the lower lip, at midline, and the mandible. The other lead was laterally displaced by approximately 4 cm. For the stimuli used, i.e., labial and nonlabial items, this recording site permitted a distinction between speech and nonspeech articulatory activity. EMG recordings were obtained with a Grass Model 7 polygraph; Model 7P3A ac preamplifier and integrator. Extraneous electrical activity and physiologic artifact below 3 Hz, at 60 Hz, and above 75 Hz were precluded by Grass Model 7 filters and a writeout maximum. Dummy electrodes were also placed on the left hands of Ss to distract attention from their mouths. A small, sensitive microphone (Wollensak 3M) was clipped on the chests of the Ss. Audible activity was recorded in the adjoining room by a Roberts 720A recorder. Ss were given a pretraining exercise to the test format until E was satisfied that the instructions were understood. They were then told to look at the slide screen for some pictures or words projected individually, and wait for a red light to go on before recalling. E tried to avoid suggesting any particular form of rehearsal or that the delay period be used at all. The E monitored audible activity during the task while simultaneously inspecting EMG

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Fig. 1. An example of two continuous EMG tracings taken from one S which shows the time markers, event markers, and EMG tracing peaks. The labial-nonlabial distinction typical of Ss as a whole is illustrated.

activity. The 12 lists, preceded by two practice series, were projected by a Carousel (Kodak AV-900) slide projector. Exposure time was approximately 2.25 sec, with an interslide interval of approximately 0.75 sec. Following each series of four slides (presentation period), Ss waited 16 sec (rehearsal period) for a red light which signaled a 14-sec overt oral recall period. A timer was also connected to one channel of the polygraph unit to record the onsets and offsets of slide presentation, rehearsal, and recall (red light) periods and thereby allow accurate classification of EMG activity by task phase. EMG muscle action potentials from the labial area were recorded on a second channel of the polygraph.

Each S was tested immediately following the experimental task to determine his ability to recognize test words. Pilot study on two Ss had demonstrated ease of picture labeling, and this was confirmed in the experiment itself through Ss' responses in oral recall.

RESULTS

The audio tapes were played so that recall data, as well as amount, temporal distribution, and nature of audible speech activity, the incidence of irrelevant utterances, and the appropriateness of Ss' labels for the stimuli, could be tabulated. Tracing and recall data were discarded in all cases of extraneous vocalization and inappropriate S-applied labels. Of the possible 312 tracings (12 Lists by 26 Ss), 270 (86.5%) were usable. Only two lists, both from the same S, were discarded because of poor word-recognition ability.

EMG Responses

The maximum EMG amplitudes (in microvolts) of the single greatest pen deflection occurring within each S's presentation and rehearsal periods for each of the 12 series of four slides were measured from the base level. In

one S which show the time markers, event markers, and EMG tracings. This sample illustrates the labial-nonlabial distinction typical of Ss as a whole.

Statistical analyses comparing the means derived for labial and nonlabial test items for each test phase (presentation-rehearsal) and stimulus-type (word-picture) condition are reported in Table 1. It is apparent from this table that mean tracing amplitudes were significantly greater for labial than for nonlabial items.³

Since the nonlabial series serves a control function, labial/nonlabial ratios were computed for each S from his mean EMG values for each test phase and stimulus type. Table 2 suggests that during both presentation and rehearsal stages, mean subvocalization was greater for pictures than for words, although the relationship was statistically nonsignificant. Further analysis showed that mean peak amplitude ratios for words were significantly greater during rehearsal than during presentation stages ($t = 2.47$, $p < .025$). The same relationship held for pictures, although it was nonsignificant ($t = 1.04$, $p > .05$).

Audio Data

Tabulation of data from the audio tapes revealed a surprisingly high incidence of (relevant) audible

whispering during the task, occurring on 64.8% of the presentation periods and on 59.7% of the rehearsal periods. There was audible whispering during either presentation or rehearsal periods on 62.7% of the picture trials and on 66.6% of the word trials.

Recall

The mean number of items recalled per condition was identical for pictures and words (3.33). On the basis of mean peak amplitude ratios, Ss were divided into two groups, the 10 Ss with the greatest labial activity and the 10 with the least. The two groups were compared on recall ability for each test phase by stimulus-type condition. There were no differences in recall scores between subvocalizers and nonsubvocalizers either for words ($t = 0.19$, $p > .05$) or pictures ($t = 0.70$, $p > .05$) when summed over test phase. There also were no significant differences between recall of words and pictures for subvocalizers ($t = 1.71$, $p > .05$) and nonsubvocalizers ($t = 0.48$, $p > .05$), although Ss who subvocalized tended to recall pictures better than words.

Following the experimental session, each S was interviewed and asked how he remembered the words and pictures. All but one S answered without hesitation that they said the words to themselves or in their minds.

Table 1
Mean EMG Tracing Peaks (μV) During the Prerecall Processing of Labial and Nonlabial Items

	Presentation		Rehearsal	
	Labial	Nonlabial	Labial	Nonlabial
<i>Words</i>				
Mean	115.66	100.91	118.59	89.13
SD	40.66	35.69	43.47	35.60
t^*		2.26		4.37
<i>Pictures</i>				
Mean	110.04	93.45	120.18	93.55
SD	41.93	35.23	44.83	37.72
t^*		2.43		3.65

*In all cases, $p < .025$ for $df = 25$ (one-tailed)

Table 2
Mean Labial/Nonlabial EMG Tracing Ratios
of Language and Nonlanguage Items
During Prerecall Processing

	Pictures	Words
<i>Presentation</i>		
Mean	1.23	1.15
t*	0.82	
<i>Rehearsal</i>		
Mean	1.31	1.30
t*	0.19	

*p > .05

Some explained that they whispered the items so softly that it was audible only to themselves. Thus, it appears that 8- and 9-year-old children not only employ subvocalization as a mnemonic strategy, but that they are conscious of it as well. It is interesting to note that two Ss said they did not whisper the items, while tapes revealed that they had indeed whispered. One S said he did whisper, but no evidence of this could be detected on the tape. One S indicated that at first he kept a visual image of the stimuli, but later adopted a whispering rehearsal strategy to enable him to remember the stimuli better.

DISCUSSION

The finding that the tracing amplitudes were significantly greater for labial than for nonlabial series supports the hypothesis presented by Locke & Fehr (1971a, b) that covert oral activity during a STM recall task is actually speech-like in nature. However, subvocalization was nearly identical in magnitude for picture labels and printed words. So, it appears that neither the grapheme-phoneme nor the picture labeling hypothesis was supported. Apparently, Ss converted both classes of stimuli into their lexical representation, and, since the lexical forms were phonemically identical for both stimulus types, the EMG tracings also were similar.

Peak amplitudes for words were significantly greater during rehearsal than during presentation, a surprising result since, as previously noted, the incidence of whispering was less during rehearsal. However, this observation substantiates the findings with adults of Locke & Fehr (1970a). Thus, it appears that the subvocalization of children in this experiment was similar, at least in this one respect, to that of adults. From later work with adults (Locke & Fehr, in press), it appears that this increase in subvocalization during the rehearsal period probably reflected Ss' attempts to retain stimuli in immediate memory

rather than a preparatory recruitment of muscles for the subsequent oral recall.

The results of this experiment indicate that there were no significant differences in recall between subvocalizers and nonsubvocalizers. This is contrary to other work (Flavell, Beach, & Chinsky, 1966; Gratch, 1966; Keeney, Cannizzo, & Flavell, 1967; Daehler, Horowitz, Wynns, & Flavell, 1969; Kingsley & Hagen, 1969; Hagen, Meacham, & Mesibov, 1970) and may have been due to the use of older Ss or a different experimental task. By the time children reach the age of 8 or 9, they may have already adopted the particular rehearsal strategy which seems to benefit them most. Therefore, subvocalizers and nonsubvocalizers may be able to memorize equally well. This would seem to be supported by some recent work with the deaf which showed that different coding strategies yielded essentially similar levels of recall but grossly dissimilar error patterns (Blanton & Nunnally, 1967; Blanton & Odom, 1968; Locke & Locke, 1971).

Further work may profitably address itself to the questions: (1) When and under what conditions do children in various environmental settings acquire the practice of subvocalizing in a task which requires recall from STM? (2) To what degree does the age of acquisition and the nature of children's use of subvocal rehearsal reflect the integrity of oral language skills and knowledge? (3) What effect, if any, does subvocalization have on the patterning of recall errors and on the accuracy of recall for items which are and are not phonetically similar in construction?

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NOTES

1. It is not known whether phonetic mediation is precipitated by speech-motor activity, acoustic imagery, or subvocalization-induced acoustic imagery. It also is possible that subvocal speech is a muscular artifact of higher level cognitive processes which themselves provide the basis for phonetic mediation.
2. Considerable work has been conducted on children's recall of pictures and words, but in most cases the words were aurally presented.
3. These means, ranging from 89 to 115 microV, exceed values from previous work (Locke & Fehr, 1970a, b) because different scales were used.