Flash-Evoked Potentials and Lipreading in Older Adults

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The purpose of this study was to investigate the relationship between lipreading scores and the latency of the third negative peak (N_3) of the flash evoked potential (FEP) waveform in older adults. FEPs were collected from 15 adventitiously hearing-impaired older adults (mean age 65.8 years), 15 normally hearing older adults (mean age 63.6 years), and 15 normally hearing young adults (mean age 23.1 years). N_3 latency measures for the two older groups were significantly longer than those for the younger group. The lipreading performance of the older hearing-impaired group and the normally hearing young group was significantly better than for the older normally hearing group. In addition, significant product-moment correlations were obtained between the N_3 latency measures and lipreading scores for the older hearing impaired group ($r = -.63$) and the younger normally hearing group ($r = -.64$). A significant correlation was not found for the older normally hearing group. These older normally hearing subjects exhibited a tendency to make errors of omission.

Because lipreading is an important means for hearing-impaired individuals to receive information, it would be helpful for rehabilitation purposes if the variables and characteristics that contribute to optimum lipreading performance could be specified. In fact, it would be ideal if procedures could be developed to quantify both the trainable and nontrainable individual factors that are involved.

Although numerous investigations have been conducted, little is known about the lipreading process or about the characteristics that make a person a good lipreader (O'Neill & Oyer, 1981). Jeffers and Barley (1971) stressed that although relationships have been found between lipreading test scores and factors such as perceptual proficiency, synthetic ability, and flexibility, these correlations have been in the weak to moderate range.

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An exception to this trend was found by Shepherd, DeLavergne, Frueh, and Clobridge (1977), who reported high negative correlations ($r = -.90$ to $-.91$) between lipreading scores on the Utley Test of Lipreading (Utley, 1946) and the latency of a late peak of the visual evoked potential. The visual evoked potential was elicited by having young normally hearing subjects watch a flashing strobe light while the resulting evoked electroencephalographic activity was recorded. Shepherd et al. (1977) concluded that lipreading performance is strongly related to the rate at which coded visual information is transmitted through the visual nervous system and they suggested that the visual evoked potential provides a means of measuring the rate.

Although Shepherd et al. (1977) referred to this procedure as averaged visual electroencephalographic response, it is more appropriately termed flash-evoked potential (FEP), because the stimuli used to elicit the response are unpatterned flashes of light that are delivered at low presentation rates. Figure 1 is an example of an FEP tracing. The response is recorded as a complex polyphasic wave that consists of several positive and negative components. While various methods have been used to identify the wave components (Ciganek, 1961; Ertl & Schafer, 1969; Shucard & Horn, 1972), we have chosen to label the peaks sequentially and with a "P" denoting positive and an "N" denoting negative polarity. Using this labeling procedure, it is the latency of the third negative peak or N_3 that has been reported to be correlated with lipreading (Shepherd et al., 1977).

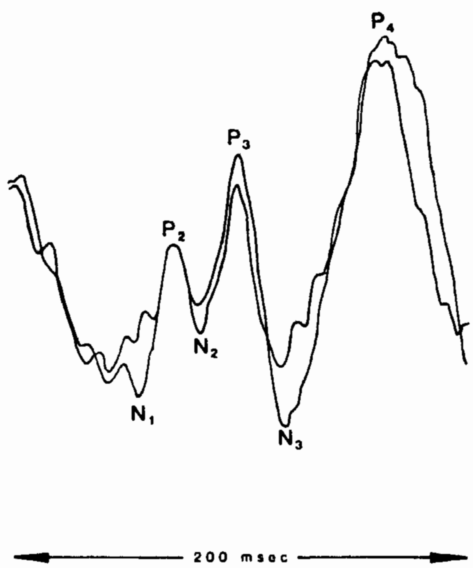

Figure 1. An example of a response evoked by flash stimuli. Positivity at the active electrode (vertex) is plotted as an upward deflection.

In a follow-up study, Shepherd (1982) found similar product-moment correlations (r=-.61 to -.89) between the latency of N_3 and scores on the Utley Test in young normally hearing adults. In a replication of Shepherd's study at The National Technical Institute for the Deaf, Samar and Sims (1983) confirmed the fundamental relationship between N_3 and lipreading in young normally hearing adults, but they found significantly weaker correlations (r=-.58 and r=-.57). In a subsequent study in which the relationship was examined in a sample of both normally hearing and severely to profoundly hearing-impaired young adults, Samar and Sims (1984) reported finding correlation between N_3 and lipreading that ranged from -.23 to -.58.

Lipreading is a complex process that involves numerous perceptual and cognitive skills so trying to predict performance on the basis of a single variable does not seem to be particularly realistic. However, in view of the high correlations reported by Shepherd et al. (1977) between N_3 and lipreading, the generality of the relationship should be further examined since it may have potential clinical use.

A group of individuals for whom FEPs may be of particular clinical importance is older hearing-impaired adults, since it is these individuals who typically rely on lipreading and who request lipreading training. Investigation of this group seems especially important since the relationship between N_3 and lipreading has not been previously examined. We questioned, therefore, whether differences in lipreading ability, N_3 latency, or the relationship between N_3 latency and lipreading are dependent on age and/or hearing status.

METHOD

Subjects

Subjects consisted of three groups of 15 persons each. All 45 individuals had 20/40 or better corrected vision and 20/200 or better noncorrected vision, as measured with a Titmus Vision Tester. In addition, all subjects were right handed, had no formal lipreading training, demonstrated no apparent speech or language difficulty, and reported no history of ophthalmological disorders.

The first group consisted of 9 female and 6 male older hearing-impaired adults (O-HI). They ranged in age from 51 to 79 years with a mean age of 65.8 years. These subjects had a mean better ear pure-tone average (500, 1000, 2000 Hz) of 39.1 dB HL re: ANSI, 1969 (range 22 to 92 dB) and a poorer ear pure-tone average of 59.4 dB HL (23 to 103 dB HL). The subjects had hearing impairments which ranged in duration from 2 to 62 years with a mean duration of 19.3 years.

The second group included 10 female and 5 male older adults with normal hearing (O-NH). They ranged in age from 51 to 75 years with a mean age of 63.6 years. Each had thresholds of 20 dB HL, or better, in both ears for 500, 1000 and 2000 Hz.

The third group was composed of 10 female and 5 male normally hearing young adults (Y-NH), who ranged in age from 17 to 33 years, with a mean age of 23.1 years. Like the O-NH group, the Y-NH group also had thresholds of 20 dB HL or better in both ears for 500, 1000 and 2000 Hz.

Procedure

Subjects were administered a silent videotaped recording of the Barley CID Everyday Sentence Test Form A (Jeffers & Barley, 1971). The sentences were spoken by an adult female speaker who had been a presenter in previous lipreading studies (Kricos & Lesner, 1982; Kricos & Lesner, in press; Lesner & Kricos, 1981) and who had been found to be easy to lipread by both young normally hearing adults and hearing-impaired teenagers.

A face-front, head-and-shoulders view of the talker, seated in front of a neutral background, was recorded on a color videotape cassette recorder (JVC 6060U). Two reflector hoods with 150-watt incandescent bulbs were placed at a 45-degree angle approximately 4 feet from the talker's mouth to supplement normal room illumination. The talker practiced the material sufficiently to insure presentation at a normal rate without exaggerated lip or jaw movements.

Subjects viewed the videotape in a quiet, well illuminated room, seated 5 feet from a 24-inch color video monitor (RCA XL100). The tape was stopped between sentences to insure that subjects had sufficient time for writing responses.

Immediately following administration of the lipreading test, FEPs were recorded. Subjects were seated in a high-backed recliner in a dimly lit room with their eyes open. Visual stimuli were presented at a rate of 3.9 per second with light emitting diode goggles containing type TLR - 107 red diodes with fresnel lenses. A fresnel lens consists of a concentric series of simple lens sections which serve to scatter the light stimuli. An accurate measurement of the flash luminance required specialized equipment that was not available; therefore, flash intensity could not be measured.

Neural activity was recorded with silver disc electrodes placed Cz to A_2 (vertex to right mastoid) with a ground electrode placed A_1 (left mastoid). Electrode impedance was less than 3000 ohms and potentials were amplified with 10^4 gain by a Nicolet physiological amplifier (HGA - 200A). Filter pass band was 5 - 100 Hz and 150 repetitions were averaged with a Nicolet clinical signal averager (CA-1000) and displayed over a 200 msec epoch. A minimum of two replications was run to insure replicability.

RESULTS

The Barley Test was scored in terms of the percentage of words correctly identified and the percentage of sentences for which the subjects had preserved the main idea. This was accomplished by awarding one point if the subject's response had essentially the same meaning as the stimulus sentence. One judge, who had had extensive experience scoring similar material prior to this experiment, scored all the sentences. The means, standard deviations, and ranges of the measures are shown in Table 1.

Table 1

Means, Standard Deviations and Ranges
of the Barley CID Everyday Sentence Test Scores in Percent

	Group		
Barley Scores	**Y-NH**	**O-NH**	**O-HI**
Word			
$\bar{X}$	38.9	25.7	36.4
S.D.	12.8	18.3	21.9
Range	12.0-53.6	0.0-54.4	4.8-78.4
Sentence			
$\bar{X}$	30.9	24.2	34.2
S.D.	11.4	18.1	22.7
Range	9.1-45.5	0.0-63.6	4.5-81.8

Lipreading scores were analyzed using a two factor analysis of variance design. The experimental groups were chosen to differ primarily along the dimensions of age and/or hearing status. Since a between-groups significant main effect was obtained ($F = 3.17$; df = 2; $p < 0.05$), the means of the lipreading scores were compared using the Scheffe procedure to determine whether age or hearing impairment contributed to this outcome. The results of this analysis indicated a significant difference ($p < .05$) between performance of the O-NH and both the Y-NH and O-HI groups. The O-NH group obtained lipreading scores that averaged 10.0% and 10.4% lower than the normally hearing young group and the hearing-impaired older group, respectively.

The poorer performance of the O-NH group was attributable, in part, to the failure of a number of subjects to respond. This was evident by the fact that 5 out of 15 of the subjects scored below 10%, compared to none of the Y-NH group and only 2 out of the 15 of the O-HI group. The 5 O-NH subjects who scored below 10% wrote an average of 9.0 words out of a possible 125 on their answer sheets, even though they were actively encouraged to guess. This can be contrasted, for example, to the Y-NH subjects, who wrote an average of 71.9 words.

The means, standard deviations, and ranges of the N_3 latency measures are presented in Table 2. Analysis of variance results indicated that a significant difference ($F = 8.85$; df = 2; $p < .001$) existed among groups. Analysis demonstrated that the Y-NH group had significantly shorter N_3 latencies ($p < .01$) than the two older groups. The latencies of the two older groups did not

Table 2

N_3 Latency Measures (In Msec)

Group	$\bar{X}$	S.D.	Range
Y-NH	134.2	10.4	116.0-158.0
O-NH	150.7	8.6	136.4-167.2
O-HI	144.7	13.2	120.8-168.0

differ significantly.

Pearson product-moment correlations were computed between N_3 latency and the Barley word and sentence scores. The correlation between N_3 and the word score for the O-HI and Y-NH groups were similar ($r = -.63$ and $-.64$) and significant ($p < .025$, $p < .01$). Coefficients of determination indicated that 40% and 41% of the variation in lipreading scores among the O-HI and Y-NH, respectively, are associated with the variation in N_3 latency. Similar results were obtained between the N_3 latency measures of the O-HI and Y-NH groups and the Barley Sentence Score (-.59 and -.49). Correlations between N_3 and both the word and sentence scores for the O-NH group, however, were low and failed to reach significance ($r = -.12$ and $-.15$).

DISCUSSION

Results indicate that there is a relationship between lipreading ability and the third negative peak of the FEP. The results obtained for the Y-NH and O-NH groups were of the same order of magnitude as those reported by Samar and Sims (1983, 1984) for normally hearing and hearing-impaired young adults, but they are somewhat weaker than those reported by Shepherd et al. (1977) and Shepherd (1983).

It is important to note that there has been quite a range in the reported strength of the relationship. The tests that have been used to assess lipreading ability would appear to be of particular importance as a contributing factor in this regard. Consider, for example, that in the present study 33% of the O-NH group scored below 10% on the Barley Test and that these subjects made few attempts to guess. Their scores would not seem, therefore, to be a true gauge of their lipreading ability. In fact, the performance of these subjects seems to underscore the fact that lipreading tests such as the Barley, offer, at best, only a general estimate of an individual's ability to lipread.

In addition, the low and nonsignificant correlations between N_3 and the lipreading scores for the O-NH group can be attributed to the failure of subjects in this group to respond. As McNemar (1969) stated, whenever the range of one of the variables being measured is restricted, the magnitude of the resulting correlation coefficient will be reduced. This tendency of the O-NH group to make errors of omission, rather than errors of commission, is consistent with other findings of response inhibition reported in the gerontologic literature (Eisdorfer, 1977). For example, when taking a hearing test, older persons have been found to be more reluctant than younger persons to respond (Craik, 1969; Rees & Botwinick, 1971; Potash & Jones, 1977). An intervention strategy, as suggested by Leech and Witte (1971), in which all responses made by older clients are rewarded regardless of whether they are right or wrong, might profitably be applied during lipreading training.

The finding of longer N_3 latencies for the two older groups is consistent with reports of a general slowing of central processing during senescence (Botwinick, 1978; Dustman, Snyder, & Schlehuber, 1981; Fozard & Thomas, 1975). Beck, Dustman, Blusewicz, and Cannon (1979) and Samar and Sims (1983, 1984) have suggested that the late components of the FEP, such as N_3, may have an "information processing" function. Their prolonged latency among older individuals may reflect central changes that contribute to the slowing of psychomotor activity. The lipreading results of the O-HI group suggest, however, that even though these subjects may have experienced a slowing of central processing as indicated by their N_3 latency measures, they lipread as well as the younger subjects who had significantly shorter N_3 latencies.

Furthermore, while there were no differences in the N_3 latencies of the two older groups, the older persons with hearing impairments lipread better than persons of comparable age with essentially normal hearing. Similar findings of differences in lipreading performance have been reported by Garstecki and O'Neill (1980) and Pelson and Prather (1974).

This difference in performance between the two older groups may have been the result of various factors. For example, it may be that individuals with hearing losses experience an increased dependency on visual cues and subsequently develop compensatory visual skills. As a result, they may tend to perform better than individuals of comparable age who have normal hearing. Alternatively, the poorer performance of the O-NH group may be due to the substantial number of group members who failed to respond. In this case, if these subjects would overcome their response inhibition tendencies, then comparable performance might result for both groups. These issues might be examined in terms of signal detection theory (Yanz, 1984) and with systematic variation of duration and degree of hearing loss.

Since lipreading is a multifaceted process that involves a complex interaction of several cognitive, linguistic, perceptual, and performance variables, it is unreasonable to expect to be able to predict performance based on a single measure such as FEP latency measures. However, it appears that a relationship does exist between the latency of the third negative peak of the FEP and lipreading scores under certain conditions with selected subjects. Continued research concerning the phenomenon would, therefore, appear to be warranted.

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