With best regards,
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AUDITORY EVOKED RESPONSE COMPARISON DURING COUNTING CLICKS AND READING[1]

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INTRODUCTION

Davis (1964) has described an increase in the amplitude of the auditory evoked response in comparing it during reading and during a high effort discrimination task.

In the past decade computer techniques have been developed which make it possible to dissect out from total EEG activity the response to specific stimuli. The resulting response characterizes neurophysiological events which are presumably the concomitants of psychological events thereby relating the perceptual activity and experience respectively. The ultimate value of this will depend upon the degree to which meaningful relationships can be established between these two parameters. This in turn will depend upon the degree of specificity of the evoked response and the refinement of methods and experiments to adequately test these relationships. Despite promising animal studies (Jouvet and Hernández Peón 1956; Hernández Peón *et al.* 1956a, b; Jane *et al.* 1962), findings in human studies have been controversial (Hernández Peón and Donoso 1959; Jouvet *et al.* 1959; Geisler 1960). Two studies were published recently which support the earlier findings that increasing attention to a light stimulus resulted in increased amplitudes of the evoked response to light (García-Austt *et al.* 1964; Haider *et al.* 1964). The latter study emphasized the value of the evoked response as an indicator of the level of attention. Davis and Yoshie (1963) did not demonstrate a clear effect of counting auditory stimuli. In his recent study, in which he presented evidence of the enhancing effect of a discriminatory task, Davis (1964) used bipolar leads and small samples of tone pips. He emphasized, in the average response, the peak to peak amplitude from the 100 msec negative to the positive peak at 150–200 msec which was increased by the discriminatory task.

While exploring the possibility of a relationship between auditory evoked response and auditory hallucinations in the acute alcoholic psychoses (Gross *et al.* 1964), the need arose to develop tasks which would reduce such variables as distraction and daydreaming and provide behavioral indicators of the quality of perceptual activity. This paper presents the results of a study of the comparison of the auditory evoked response to clicks in normal subjects during counting clicks and reading. Our experimental hypotheses were that actively directing the subject to the stimulus as compared to directing the subject to a casual task away from the stimulus, would increase the amplitudes, decrease the duration, and decrease the latencies of the response.

SUBJECTS AND METHOD

Eleven young adult, white, male college students were studied. They were seated in an acoustically shielded enclosure beneath a loudspeaker which presented a stimulus of 0.2 msec duration and an intensity of 90 db with reference to 0.0002 dynes/cm^2 every 1.55 sec. Monopolar determinations were obtained utilizing as the active lead an electrode placed 5 cm to the left of the midline along an imaginary line connecting the two external auditory meati. The reference electrode was the two ear lobes combined. Resistances were kept below 5000 Ω.

The physiologic recorder used was a Grass Model P-7. The muscle filter was used at all times and surges of greater than 100 μV were

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clipped. Computation was done with a magnetic drum average response computer developed in our laboratory (Tobin 1961). Each subject had the following sequence of tests: two determinations of the averaged response to 700 clicks while reading (in conjunction with another study); two determinations of the averaged response to 270 clicks while reading; one determination of the averaged response to 270 clicks while counting the clicks. The subjects counted to themselves with eyes open in series which kept increasing by 5: 1–5, 1–10, 1–15, etc. At the end of each series the subject pressed a button which triggered a signal on the same pen which recorded the stimuli. This may be described as a low effort task in which each incorrect count was scored as an error. In the total of 110 individual tasks only three errors were made, in contrast to the considerable number of errors made in the tasks described by Haider *et al.* (1964) and Davis (1964). García-Austt *et al.* (1964) do not indicate the number of errors made in counting light flashes but it seems reasonable to assume this was a low effort task.

The evoked response was displayed on an oscilloscope and photographed at different time bases from time zero to 100, 250, 500 and 2500 msec.

The evoked response is multiphasic, regularly consisting of five components: a positive peak at 30 msec, a negative peak at 60 msec, a positive peak at 100 msec, a negative peak at 160 msec and a positive peak at 220 msec (times are approximate). This yields four successive peak to peak amplitudes (designated A–D), a total duration of the response which corresponds to the positive peak at 220 msec, and four successive latencies (designated 1–4).

It seems reasonable to consider that many complex variables may effect the characteristics of the evoked response and so two determinations of the response during reading were obtained, the average of which was used in the comparison with the response to counting.

RESULTS

There was a high reliability coefficient between two independent judges for the measurement of the amplitudes (0.83) and the latencies (0.90). In the two studies of reading (N=270) the test-retest reliability coefficients were significantly high for all amplitudes, total duration of the evoked response, and all latencies. Coefficients for amplitudes A, B, C, and D were 0.74, 0.92, 0.86, 0.77 respectively. The coefficients for latencies 1, 2, 3 and 4 were 0.90, 0.97, 0.89, and 0.72 respectively while for total duration it was 0.68. The latencies and duration in one subject could not be measured by either of the judges because of the marked shifts in the configuration of the response.

The difference between the two means for correlated samples yielded a t score with $p < 0.01$ for amplitude A and $p < 0.05$ for amplitudes B, C and D, and total duration (see Table I).

There was a statistically significant difference between the standard deviations of latencies 1–4 during reading as compared to counting clicks. The significance of the difference between correlated variances (McNemar 1962) yielded a t score with $p < 0.01$ for latencies 1, 2 and 3, and $p < 0.05$ for latency 4. The SD increased for latencies 1, 2 and 3, and decreased for latency 4 (see Tables I and II).

In contrast to the amplitudes and total duration of the response, the range of values of latencies 1–4 yielded statistically significant variability in the comparison of reading and counting clicks (See Table II). Non-parametric statistical analysis did not reveal a significant change in any of the mean latencies.

TABLE I

Summary of amplitude results obtained during reading and counting

	Amplitude*			
	A	B	C	D
Mean reading	9.0	11.2	8.9	7.2
Mean counting	11.4	12.9	10.8	8.4
SD reading	3.5	6.0	4.4	2.7
SD counting	4.7	7.5	5.9	3.7
t (means)	3.31**	2.26***	2.57***	2.35***

* Amplitude scale: 10 units = 3.4 μV.
** Significant <0.01
*** Significant <0.05
df = 9

TABLE II

Summary of latency and duration results obtained during reading and counting

	Latency 1	Latency 2	Latency 3	Latency 4	Duration
Mean reading	33.9	76.4	110.5	171.0	229.3+
Mean counting	34.6	79.7	108.0	168.7	219.6+
SD reading	6.2	6.5	9.5	7.9	20.5
SD Counting	10.5	11.7	14.0	3.6	15.2
t (variances)	3.8***	5.6***	12.6***	2.8**	0.75*

* Not significant at 0.05
** Significant <0.05
*** Significant <0.01
+ Difference between mean duration for reading and counting. $t = 2.27$. Significant at <0.05 level. df = 8

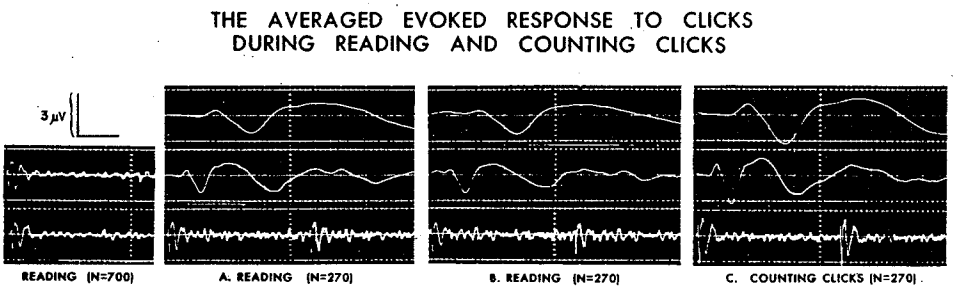

Fig. 1

Comparison of the characteristic effect of reading and counting clicks on the amplitude of the auditory evoked response in one of the subjects. The column at the far left shows the first two determinations of the evoked response during reading, each of which is the averaged response to 700 clicks. Approximately the first 1500 msec are shown. These determinations demonstrate the improved signal to "noise" ratio frequently achieved by the increased number of stimuli averaged. The three other columns each represent the averaged evoked response to 270 clicks. In each column the top response is a time gate of 100 msec, the middle response is 250 msec, and the bottom response is 2500 msec and repeats the response after the interstimulus interval. The stimulus marker is seen below the onset of the response. Upward deflections are negative.

Fig. 1 illustrates a set of responses obtained from one of the subjects. This example demonstrates the increased amplitudes but does not demonstrate the decreased duration of the evoked response.

DISCUSSION

The data would seem to confirm the hypothesis that directing the subject to count the clicks produces greater amplitudes and shorter duration of the auditory evoked response than obtained during reading. The hypothesis that latencies 1–4 would be decreased was not confirmed.

It remains to be determined if the neurophysiological mechanism involves the increased stabilization of temporal functions and/or a true increase in activity of the evoked response and/or the decrease in background activity (Brazier 1964). It also remains to be

determined what the psychophysiological mechanisms are. What aspect of the change in the evoked response is related to the neurophysiologic concomitant of the mental activity of counting? What is the role of the increase of the general state of alertness resulting from the shift from a casual to a more demanding task? How much and what part of the change is related to specific concentration on the stimulus itself which in turn would be related to the actual perceptual experience? What aspects of the evoked response, if any, are related to the activities of coding and registration (memory?). Observations we have made suggest that amplitudes A and B are more closely related to the actual perceptual experience than are amplitudes C and D (Gross *et al.* in preparation). Further studies are in progress to try to determine the specific relationships indicated above.

Another observation that requires further study is the variability of the characteristics of the evoked response. The variability of all amplitudes showed no significant change. Latencies 1, 2 and 3, showed a statistically significant increase in variability, while latency 4 showed a statistically significant decrease in variability. The variability of the total duration showed a decrease, but this was not statistically significant.

SUMMARY

The shift from a casual task directed away from auditory stimuli to a task requiring a low order of effort directed to the auditory stimuli produced significant changes in the 4 major amplitudes and the total duration of the auditory evoked response.

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