The Auditory P300 at or near Threshold

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Abstract

Psychophysical and P300 (P3) thresholds and suprathreshold measures were obtained in 16 normal-hearing subjects. Subjects followed a classic oddball paradigm using 1000 (frequent) and 2000 Hz (rare) tones as stimuli. The P3 was obtained for all 16 subjects at or 5 dB above their behavioral threshold. The P3 was obtained more often at behavioral threshold and 5 dB SL than N1 and P2 late potentials. The P3 was larger in amplitude than either the N1 or the P2 at threshold and for 75 dB SPL stimuli. In comparing P3s obtained at threshold and for the 75 dB stimuli, significant effects were noted in latency and amplitude reflecting exogenous aspects to this endogenous potential. Differences in latency and amplitude were also noted in N1 and P2 waveforms obtained from the rare versus frequent stimuli. Clinical implications of these results are discussed.

Key Words: Endogenous, evoked potentials, exogenous, N1, P2, P300 (P3), threshold

Sumario

Se obtuvieron mediciones psicofísicas así como umbrales y mediciones supra-umbrales de la onda P300 (P3) en 16 sujetos normo-oyentes. Los sujetos siguieron un paradigma clásico y peculiar utilizando como estímulo tonos de 1000 Hz (frecuente) y de 2000 Hz (infrecuente). La P3 se obtuvo para los 16 sujetos a nivel de umbral conductual o a 5 dB por encima de éste. La P3 se obtuvo más a menudo a nivel de umbral conductual y a 5 dB SL, que los potenciales tardíos N1 y P2. La P3 fue mayor en amplitud que la N1 o la P2 a nivel umbral, y para estímulos de 75 dB SPL. Al comparar las P3 obtenidas a nivel umbral y con estímulos de 75 dB, se notaron efectos significativos en latencia y amplitud, que reflejaban aspectos exógenos de este potencial endógeno. Se notaron también diferencias en latencia y amplitud en las formas de onda N1 y P2 obtenidas de estímulos infrecuentes versus frecuentes. Se discuten las implicaciones clínicas de estos resultados.

Palabras Clave: Endógeno, potenciales evocados, exógeno, N1, P2 P300 (P3), umbral

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Threshold of the auditory P300 (P3) evoked response has rarely been explored in relation to absolute behavioral threshold. However, studies have been conducted on the effects of the acoustic stimulus on the P3 for both oddball and signal detection paradigms (Hillyard and Picton, 1987). Although little absolute threshold data are available on P3s, considerable research has been published comparing the late auditory N1, P1, and P2 potentials with audiometric thresholds (Davis et al, 1967; Beagley and Kellogg, 1970; Schimmel et al, 1974; Reneau and Hnatios, 1975). Suzuki et al (1976) and numerous others have reported that N1, P1, and P2 evoked responses were elicited within 10 dB to 30 dB of psychophysical threshold (Reneau and Hnatios, 1975). Suzuki et al (1976) found that the P1 and P2 evoked responses were present within 10 dB of audiometric threshold in 71% of their subjects, and were within 30 dB of threshold in 97%. Beagley and Kellogg (1970) reported late potentials within 5 dB of behavioral threshold (using the speech frequency average as threshold) by using a method in which auditory stimuli crossed threshold in 10 dB steps. However, they did not report how frequently these results were obtained in their subjects. Cody and Bickford (1964) using the N1, P2 response reported that over 80% of their subjects demonstrated evoked potential thresholds within 5 dB of behavioral threshold. All subjects had late potential response within 15 dB of behavioral threshold. Similar findings were reported by McCandless and Lenz (1968) and McCandless (1978) for adults and children.

The auditory P300 (P3) is typically considered to be an endogenous evoked potential. Traditionally, endogenous potentials are thought to be nonobligatory, that is, the same stimulus may or may not elicit them depending on their role in the subject's task. Additionally, the amplitude, latency, and scalp distribution of the P3 components do not depend on the physical characteristics of the eliciting stimulus (Donchin et al, 1978). Conversely, the characteristics of exogenous evoked potentials are generally thought to be highly dependant on the stimulus parameters (Donchin et al, 1978). Polich et al (1996) states, “the influence of stimulus variables on these results has been little addressed, since the P300 ERP component is assumed to be relatively immune to the effects of stimulus factors because of its putative endogenous rather than exogenous origin.” However, the validity of this classification has recently been questioned (see discussion).

The auditory P3 has been investigated most often in disorders of the brain and cognitive function, even though its neural generators are not yet fully understood (McCarthy et al, 1989; Knight et al, 1989; Wood, 1984). The P3 has been described in dementia, alcoholism, drug effects, hyperkinesias, Alzheimer's disease, Down's Syndrome, various psychiatric disorders, aging, and aphasia (Goodin et al, 1978; Herning and Jones, 1978; Loiselle et al, 1979; Pfefferbaum et al, 1979; Chayasirisobhom et al, 1985; Diner et al, 1985; Lincoln et al, 1985; Romani et al, 1987; Patterson et al, 1988; Polich and Starr, 1984; Selinger and Prescott, 1989).

While the relationship between the P3 response and subjective auditory threshold has not been investigated, other psychophysical attributes of the P3 have been studied with reference to intensity in general. Studies on signal detection (Kerkhof and Werner, 1978) and comparison of random stimulus intensity with a loudness reference (Pratt and Sohmer, 1977), while valuable, did not yield information about the P3 in relation to audiometric threshold. Squires et al (1973), in a signal detection paradigm, showed the P300 amplitude to vary as a function of the confidence in the detection of the target signal. Backs (1987), Polich (1986, 1989), and Polich et al (1996) found that, in general, P3 amplitude increased and latency decreased with increments in stimulus intensity, but threshold measurements were not the aim of the study. Threshold information seems necessary, not only to further enhance our understanding of the P3 results in reports such as those mentioned above but also to determine the association of P3 amplitude and latency to audiometric behavioral threshold. It is also important to ascertain the value of using the auditory P3 evoked response as an indicator of hearing threshold level in populations that cannot respond to conventional behavioral test methods. Also, to better compare results of studies using the P3, it must be determined how much above subjective threshold a stimulus has been presented. That is, if there are intensity effects on the P300 and different studies use different intensity levels, valid...
comparison of these studies may be difficult. The attention factor (as represented in the oddball paradigm) and how it effects the late potentials (N1, P2) at threshold also seems to be important. Moreover, further investigation seems warranted to help determine whether the P300, long considered an endogenous evoked potential, also has an exogenous component.

This study is designed to compare the auditory P3 evoked potential elicited by an oddball paradigm with audiometric behavioral thresholds in a group of normal subjects. The P3 was also compared with N1 and P2 for amplitude and latency at threshold and suprathreshold levels. Amplitude and latency measurements at threshold and suprathreshold were also analyzed to determine any exogenous (intensity) effects on the P3.

SUBJECTS

Sixteen subjects volunteered for this project. The ages of the subjects ranged from 12 to 43 years with a mean age of 27 years. The group included nine males and seven females with behavioral audiometric thresholds of 20 dB HL or better for octave frequencies 250 Hz through 8000 Hz. None of the subjects had any history of otologic or neurologic problems. This study was approved by Dartmouth Hitchcock Medical Center Institutional Review Board.

PROCEDURES

All subjects were tested while seated in a sound-treated IAC room. The acoustic stimuli were 1000 and 2000 Hz tones with a 10 msec rise/fall time and a 20 msec plateau. These stimuli were presented to subjects at a rate of one tone every 800 msec through an ER-3A ear insert phone placed in the ear canal. A traditional oddball paradigm was used to obtain N1, P2, and P3 responses with the frequent tone (1000 Hz) occurring in 85% and the rare or target tone (2000 Hz) in 15% of the total number of accepted presentations (300). All subjects were given proper orientation to the task.

Only one ear per subject was tested, and the selection of right or left ears was randomized. The subjects were instructed to count the number of rare (2000 Hz) tones heard and to report this number to the examiner at the end of the run. All subjects in the study met the criterion of 95% or better for reporting the correct number of rare tones. Examiners confirmed that each subject could easily discriminate between the rare and the frequent tone. To minimize eye movement, subjects were asked to visually fixate on a picture located directly in front of them, approximately 1.3 meters away.

Behavioral thresholds using the P3 stimuli were established on each subject employing a modified Hughson Westlake procedure (Carhart and Jerger, 1959). These thresholds were independently established for 1000 Hz and 2000 Hz stimuli. Next, replicated N1, P2, and P3 waveforms were obtained for a 75 dB SPL stimulus for all subjects (behavioral threshold for the subjects ranged from 0 dB SPL to 15 dB SPL). These suprathreshold recordings were used to help determine intensity effects and also were used as references in determining threshold responses. Electrophysiological responses were then recorded, beginning at behavioral threshold levels (for 1000 Hz and 2000 Hz tones) and increasing in 5 dB steps until a replicable N1, P2, or P3 waveform could be recorded. The lowest intensity level for which there was an N1, P2, or P3 response was considered electrophysiologic threshold (Fig. 1). However, not all three waves were necessarily present at this level. Control

![Figure 1. An example for N1, P2, P3 waveforms for 75 dB SPL and electrophysiologic threshold for rare and frequent stimuli from one subject in the study.](image-url)
trials of no stimulus were also obtained from the subjects for comparative purposes. Two individuals well experienced in auditory evoked potential recordings were asked to decide whether N1, P2, or P3 waves were observable in order to determine the electrophysiologic threshold. If there was disagreement or uncertainty between the judges, then the traces at higher intensity levels were considered until agreement was reached. In addition, waveforms had to occur between 80 msec and 150 msec for N1, between 150 msec and 260 msec for P2, and between 250 msec and 420 msec for P3 to be considered for threshold determination. These latency ranges were selected based on pilot data. The latency criteria added interpretive constraints on the determination of threshold waveforms. Both rare and frequent results were obtained for the N1 and P2 waves. Only rare results for the P3 were included for analysis.

Neuroelectrical activity was recorded through electrodes attached to the vertex (positive) and referenced to the earlobe of the acoustically stimulated ear. The ground electrode was placed at the midforehead. Impedance across the electrode array was maintained at less than 8000 Ohms for all subjects. Filtering of neural activity was accomplished using Butterworth filters set at 1 to 30 Hz with a 12 dB per octave rolloff. Filter cutoff points were 3 dB down. Attempts were made to extend the high-pass filter below 1 Hz, but noise and increased artifact became a problem in some subjects. A Nicolet Compact Four was used as the averager. Waveforms were displayed on an 800 msec time window and stored disk for analysis. Artifact reject was set at 45 μ volts to help eliminate eye blink artifacts.

Measurements of latency were taken from the onset of the stimulus to the peak of the wave to be measured. If the peak was bifid (P3a P3b, which was occasionally the case for the P3 at the higher intensity level), the larger of the two peaks was used. The N1 amplitude was computed from the P1 peak or to the following negative trough. The P2 amplitude was measured from the N1 trough to the P2 peak and the P3 amplitude from the N2 trough to the P3 peak, then down to the following trough. An average of the front and backsides of the wave was derived to provide the P3 amplitude measure. N1 and P2 waveforms were measured for both the rare and the frequent stimuli.

All waveforms were replicated. Waveform responses were recorded from both the frequent stimuli (N1 and P2) and rare stimuli (N1, P2, and P300). If there were differences in amplitude or latency measures between initial and replicated trials, an average between the two traces was taken.

The data were analyzed by descriptive statistics in regard to the presence or absence of waves. The Student’s paired t-test was used to determine significance (p < 0.05) in comparing latencies and amplitudes of the various waves at high and low intensity levels.

RESULTS

Latencies and amplitudes for the N1, P2, and P3 evoked response waveforms to the 2000 Hz rare tone used in the oddball paradigm were measured and compared for the 75 dB SPL intensity level and at the lowest intensity level at which each subject demonstrated readable waveforms for N1, P2, or P3. The P3 was the only one of the three evoked responses studied that was present in all 16 subjects for the rare stimuli at both the 75 dB SPL level and at electrophysiological threshold (0 dB or 5 dB in reference to behavioral threshold). In many cases, true threshold (behavioral and electrophysiological) can not be obtained using the 5 dB steps. Therefore, the reported SLs will have a margin of error due to the 5 dB step methodology used. Latency and amplitude comparisons between the two intensity levels in response to the frequent 1000 Hz tone in the oddball paradigm were made for the N1 and P2 evoked waveforms.

Latency

At 75 dB SPL the N1 waveform response to the rare tone was observable for 15 of the 16 subjects. Tables 1 and 2 provide the number of subjects providing a response at 0 and 5 dB SL (re: behavioral threshold), as well as the latency data. In every subject in whom evoked responses were present at both intensity levels of stimulation, latency for the threshold level waveform was longer than for the 75 dB SPL evoked waveform (Fig. 2). This difference between threshold and suprathreshold latencies was statistically significant (t = -4.61, p < 0.05).

The P2 evoked response to the rare tone
was present in all subjects at 75 dB SPL. Tables 1 and 2 show the number of subjects with responses at or near threshold, as well as the latency data. Again, the latency at the threshold intensity level was longer than at suprathreshold levels in all subjects in whom both waveforms were present. This difference was statistically significant ($t = -3.12$, $p < 0.05$).

All 16 subjects had P3 evoked responses to the rare tone at 75 dB SPL. Table 1 shows the number of subjects with P3s at 0 and 5 dB SL. Table 2 shows the effects of intensity on P3 latencies. This difference in latencies at high and low intensities was statistically significant ($t = -7.83$, $p < 0.05$).

Latency measurements for the evoked response to the frequent 1000 Hz tone were made for N1 and P2. The N1 evoked response for the 75 dB SPL stimuli was present in all subjects. However, this was not true at threshold (Table 1). Latencies were greater for low intensities than for high intensities (Table 2). This difference between 75 dB SPL and threshold was statistically significant ($t = 3.44$, $p < 0.05$). The P2 response to the frequent tone was also observed in all subjects at the 75 dB SPL intensity level and in 14 subjects at 0 or 5 dB SL (Table 1). Latencies were greater for low intensities than for high intensities (Table 2). Again, this difference was statistically significant ($t = -7.34$, $p < 0.05$). More subjects had N1 and P2 evoked responses to the frequent tone than to the rare tone.

In summary, the latencies for the N1, P2, and P3 evoked responses to the rare tone in the oddball paradigm were all significantly longer at electrophysiological threshold levels than at 75 dB SPL (Fig. 2). The same held true for the N1 and P2 evoked responses to the frequent tone.

### Table 1. Number and Percentage of Subjects with N1, P2, or P3 Responses at Two Sensation Levels with Regard to Behavioral Threshold

<table>
<thead>
<tr>
<th>SL</th>
<th>RARE STIMULI</th>
<th>FREQUENT STIMULI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N1</td>
<td>P2</td>
</tr>
<tr>
<td>0</td>
<td>3 (18.8%)</td>
<td>4 (25%)</td>
</tr>
<tr>
<td>5</td>
<td>6 (33.3%)</td>
<td>6 (33.3%)</td>
</tr>
<tr>
<td>Total</td>
<td>9 (56.3%)</td>
<td>10 (62.5%)</td>
</tr>
</tbody>
</table>

*Note: SL = sensation level.*

### Table 2. Mean Latencies of N1, P2, and P3

<table>
<thead>
<tr>
<th></th>
<th>N1</th>
<th>P2</th>
<th>P3</th>
</tr>
</thead>
<tbody>
<tr>
<td>RARE</td>
<td>75 dB SPL</td>
<td>Threshold</td>
<td>75 dB SPL</td>
</tr>
<tr>
<td>N1</td>
<td>97.5 (8.3)</td>
<td>117.9 (9.7) +</td>
<td>102.3 (9.6)</td>
</tr>
<tr>
<td></td>
<td>[90–112]</td>
<td>[93–123]</td>
<td>[90–125]</td>
</tr>
<tr>
<td>P2</td>
<td>167.4 (6.7)</td>
<td>192.9 (24.6) +</td>
<td>191.8 (18.4)</td>
</tr>
<tr>
<td></td>
<td>[184–196]</td>
<td>[163–212]</td>
<td>[160–220]</td>
</tr>
<tr>
<td>P3</td>
<td>298.6 (17.9)</td>
<td>342.2 (17.8) +</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[278–328]</td>
<td>[322–382]</td>
<td></td>
</tr>
</tbody>
</table>

*Note: All values in msec; () = standard deviation; [ ] = minimum-maximum latencies; + = statistically significant (<.05).*
Amplitude

Amplitudes for the P2 and P3 for the rare stimuli were greater at 75 dB SPL than at threshold (0 or 5 dB SL) (P2, t = 7.21, p < 0.05; P3, t = -5.51, p < 0.05). Only for the N1 did this difference not reach statistical significance (Table 3). Amplitudes for the N1 (t = 5.57, p < 0.05) and P2 (t = 5.46, p < 0.05) for frequent stimuli were significantly greater at the higher intensity (75 dB SPL) (Table 3).

In summary, the amplitudes for the P2 and P3 waveforms for the rare tone were significantly greater for the 75 dB SPL intensity level than for the threshold level (Fig. 3). The N1 and P2 amplitudes for the frequent tone were also significantly greater at 75 dB SPL than at electrophysiologic threshold.

Also, the N1 and P2 responses generated from the rare stimuli occurred earlier and with greater amplitude than those resulting from the frequent stimuli (Figs. 2, 3). Figure 1 depicts a representative waveform of the late potentials and P3 at threshold and suprathreshold levels.

DISCUSSION

The focus of this study and its results relate to the threshold level P3 evoked response and secondarily to intensity effects on this “endogenous” potential. First, the P3 was observable and measurable in all subjects at behavioral threshold or 5 dB above threshold, whereas N1 was present only in nine subjects and P2 in ten subjects at the same intensity levels (rare stimulus). One could argue that if more averages were done providing an improved signal-to-noise ratio, more N1 and P2s could be observed. This may explain why there were more subjects with N1 and P2 responses for the frequent stimuli despite the fact that these responses were smaller in amplitude. However, one must also consider that the P3 still yielded more observable responses with only 45 trials. Second, not only was the P3 evoked response to the rare tone always present, but its amplitude at the threshold level of presentation was also significantly greater than the threshold level amplitude of either N1 or P2 at the same level. In fact, the P3 amplitude to the threshold level presentation of the rare tone was significantly larger than even the amplitudes of N1 and P2 at the 75 dB SPL level for the rare stimuli (p < 0.05).

The implication of these threshold findings is that the P3 is considerably robust...
and easily identified at threshold. Therefore, in clinical situations where the oddball paradigm can be followed, the P3 could provide auditory information that closely approximates behavioral pure-tone thresholds. Of course, the necessary cognitive processing associated with the oddball paradigm would have to be achieved to obtain these robust P3 responses.

The N1 and P2 evoked responses can be elicited without the cognitive processing required by the oddball paradigm used to evoke the P3 response. The P3 amplitude is probably enhanced by the event-related cognitive task that requires greater subjective attention and neural activity than the mere detection or recognition of a stimulus. Hillyard and Picton (1987) suggested that the increased amplitude for evoked potentials for stimuli that were attended to was related to preferential admission of sensory input along one channel while suppression occurred for inputs from other channels.

The effect of intensity on the N1, P2, and P3 evoked responses was observable in both latency and amplitude measurements throughout this study. This was not unexpected, especially for N1 and P2 waves due to the considerable difference in intensity between the 75 dB SPL and the electrophysiologic threshold level stimuli (McCandless and Lenz, 1968; Backs, 1987; and Polich, 1989). Latency and amplitude for the evoked responses to both the rare and the frequent tones in the oddball paradigm were affected by intensity. In the N1 and P2 waveform responses to the frequent tones, amplitudes were smaller and latencies longer than for responses to the rare tones. This result concurs with past research indicating that the neural response to frequent stimuli decreases as habituation occurs (Mountcastle, 1968). It is also well known that focus of attention will affect the amplitude of the late potentials (Hillyard and Picton, 1987; Polich, 1989). In this study there was more attention and related cognitive processes to rare than to frequent stimuli, which could explain the larger and earlier N1 and P2 responses to the rare stimuli. The shorter latency of the evoked potentials generated by the rare stimuli also could, in part, be due to the fact they were of a higher frequency, but this would have a minimal effect if any (see Jacobsen et al, 1992). It is more likely that the shorter latencies for N1, P2 generated by the rare compared to frequent stimuli was associated with endogenous factors (McCandless and Best, 1966; Polich, 1989).

Across subjects there was great variability in the amount of latency shift from 75 dB SPL intensity level to the threshold level. The shift was greater for P2 and P3 (vs. N1) for the rare tone and for P2 (vs. N1) for the frequent tone. There was also wide intersubject variability in the amount of amplitude increase related to the intensity increase from threshold level to the 75 dB SLP level. Again, the later in time the cortical response, the greater the variability among subjects for the evoked responses to both the rare and the frequent tones. Thus, in response to the rare tone, the amplitude increase for P2 with the intensity increment from threshold level to 75 dB SPL was greater than that for N1, and the P3 amplitude difference was greater than that for P2. For the frequent tone, the P2 evoked response increased more with the higher intensity stimulus than did the N1 response across subjects.

The influence of intensity on the generators of N1, P2, and P3 is not straightforward and therefore may be the basis for the variability noted in this study. In the primary auditory cortex, there are partial relationships between intensity increments and neural firing. Some neurons increase their discharge rate with increases in intensity up to a certain level, then the discharge no longer increases with further intensity increments. Other neurons stop firing altogether when intensity increases or when the rate of discharge decreases (Pickles, 1982; Parasuraman and Jackson, 1980). Some neurons in the auditory cortex do not fire below threshold, while other neurons fire spontaneously at subthreshold levels. Approximately 75% of auditory cortex neurons have similar rate-intensity functions as auditory nerve fibers. In 50% of cortical neurons, as intensity increases, the firing rate increases until saturation is reached; the remaining 50% of the neurons maintain a steady firing rate (or decrease) despite increases in intensity (Brugge and Reale, 1985). Thus, the relationship between intensity and amplitude of the late cortical evoked responses might be difficult to interpret and more complex than one might assume. Also, apparently the later the neural
response to stimuli, the greater the variability in the relationship between stimulus intensity and evoked response amplitude. This may be related to the concept that the greater the latency, the greater the number of cortical interactions. Therefore, complex intensity and also complex endogenous functions contribute to variability of the late potentials in regard to amplitude (Polich and Starr, 1984; Polich et al, 1989).

Latency generally decreases as intensity of the stimulus increases. Although this response occurred in individual subjects, similar to amplitude, there was considerable variability among subjects between stimulus intensity (75 dB SPL vs. threshold level) and latency. The later in time the evoked response, the greater the intersubject variability. Again, the later cortical responses depend on more processing and probably involve more diverse neural generators. The P3, which showed the greatest variability among subjects in regard to intensity change, depends on cognitive activity involving memory, decision making, and attention, and not merely on stimulus detection. However, it is important not to lose sight of the fact that intensity clearly influenced the latency and amplitude of the N1, P2, and P3 waveforms. The effect of intensity changes of the acoustic stimulus on the P3 highlights the issue of endogenous versus exogenous evoked potentials.

It has long been accepted that the P300 is an endogenous evoked potential while the earlier evoked potentials are considered exogenous. Strict interpretation of endogenous would mean intensity of the stimulus would not greatly influence the P300 latency or amplitude. However, studies by Roth et al (1982), Polich (1989), and Polich et al (1996) indicate that intensity change does influence the latency and amplitude of the P300. As stated by Roth et al (1982), “the P3 behaved like an exogenous component” in that intensity had a profound effect on its amplitude and latency. The findings from the present study support the reports of Roth et al and Polich. Therefore, it may be reasonable to consider that the P300 is not only an endogenous but also at least in part an exogenous potential.

If there is an exogenous component to the P300, is there anyway to quantify it? It is interesting to speculate on this question given the findings from the present study. If at threshold one could assume there is minimal acoustic (exogenous) influence or contribution to amplitude, then at 75 dB SPL one could assume that there would be a maximal exogenous contribution. (It has been shown that amplitude of the P3 increases little at intensity levels above 75 dB SPL [Backs, 1987; Polich et al, 1996]) However, the endogenous influence on the P300 should be similar at both threshold and suprathreshold levels (i.e., attentional allocation should be similar at threshold and suprathreshold levels because the task remains the same). Therefore, if the P300 amplitude at threshold was subtracted from the amplitude at 75 dB SPL, the remaining voltage could be interpreted at the exogenous contribution. The exogenous contribution for latency could be derived in the same manner.

Certainly one could argue that attention and other endogenous factors may not be similar at threshold and suprathreshold levels. It would seem, however, if attention is not the same at the two intensity levels, it would be greater at threshold than suprathreshold (more intent listening). Looking at this notion another way, it seems reasonable that at threshold the exogenous (acoustic) component would be minimized while at 75 dB it would be maximized.

CONCLUSION

The results of this study show that the P3 evoked response to the oddball paradigm is a robust potential, even at threshold levels of presentation. At threshold levels it is observable in more normal subjects (in all subjects in this study) at much greater amplitude than either the N1 or the P2 evoked response. Therefore, the P3 would seem to be the best choice among the late cortical potentials for threshold determinations in patients of any age who can perform the simple counting task of the oddball paradigm but who may not be able to respond consistently to the more conventional audiometric methods. This might apply to the severely hearing impaired, such as those individuals who are candidates for cochlear implants. It might also apply to certain cognitively challenged individuals. Focusing attention on the task certainly can be a limitation of the P3 in regard to its possible clinical use.

Measurements made at threshold may also prove to be more sensitive than
suprathreshold measures in certain populations. This might be expected in specific types of neurologic pathologies (Musiek et al, 1992) and/or in cases of higher auditory processing deficits (Jirsa, 1992).

There are several implications, relevant to P3 research, which can be made based on the results of the present study. First, threshold information as well as latency and amplitude effects on the P300 are critical to know for comparisons across different studies. If similar intensity levels are not employed, then differences in results could be related to exogenous rather than endogenous components. Second, this study supports other studies that demonstrate a probable exogenous component to the P300 based on both amplitude and latency changes related to changes in intensity of the acoustic stimulus.

REFERENCES


Auditory P300 at or near Threshold/Musiek et al


