Auditory P300 development from an active, passive and single-tone paradigms

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Abstract

The P300 (P3) event-related brain potential (ERP) was elicited with auditory stimuli in order to compare three different tasks and to assess the effect of ageing from childhood to adolescence. Seventy-two subjects, ranging in age from 6 to 14 divided into three age groups, were selected for this study. In the active task, the subject was required to discriminate between standard and target tones (oddball); in the passive task condition, the subject did not respond to either the standard or target stimulus; in the single task, a target but not a standard tone stimulus was presented and the subject was required to react to the target tone. Our results show that the passive sequence and the single-tone paradigm yielded similar P300 waveform to those obtained from the active task. Separate age/ERP component latency and amplitude linear regression were computed. A significant negative correlation between age and P3 latency was found. The event-related potential P3 wave shows consistent and significant age-related changes in human cerebral function, regardless of the methodology used. These findings suggest that the passive and single-tone paradigms can be a useful way to elicit the P3 ERP component. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Event related potentials (ERPs); P3(00); Active paradigm; Passive paradigm; Single-tone paradigm

1. Introduction

The event-related potential (ERP) contains a late positive wave that has been called P3 or P300 (Sutton et al., 1965; Squires et al., 1975; Sutton, 1979). P3 reflects fundamental information when processing events associated with memory operations (Klein et al., 1984; Johnson, 1986; Donchin and Coles, 1988). Two basic types of P3 waves are described; the P3a and P3b components. The former has an amplitude maximum in the frontal regions, and is elicited by rare, novel stimuli, 'frontal' or 'novelty' P3 or P3a. The classic P3

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wave, on the other hand, is largest over the parietal area, 'parietal P3 or P3b', and is elicited by rare and task relevant stimuli (Knight, 1984).

In the vast majority of the studies, a simple two-tone auditory discrimination paradigm is used to elicit the P3 called the 'oddball' paradigm (e.g. Squires et al., 1976; Johnson and Dohin, 1978; Woods et al., 1980). In this situation, the subject is required to count mentally and to discriminate a target tone from a nontarget stimulus. The oddball paradigm is easily performed by normal control subjects. However, there are problems when it is used with uncooperative subjects (Duffy et al., 1984). In an attempt to solve these difficulties some studies have proposed different ways to elicit a P300 using less complex task demands.

A variety of reports have demonstrated that a P3 component can be obtained from 'passive' procedures that do not demand an active intentional discrimination response (e.g. Ritter et al., 1968; Polich, 1987, 1989; McIsaac and Polich, 1992; Fugichami et al., 1995). Passive paradigms induce an automatic target/standard discrimination by making the target stimulus very different and/or relatively infrequent compared to the standard stimulus (Polich et al., 1993). Several studies have compared the P3 waveform elicited by passive and active tasks in ageing (O'Donnell et al., 1992) and in clinical populations (Papanicolaou et al., 1984; Surwillo and Iyer, 1988; O'Donnell et al., 1990a). A reasonable agreement between the two task conditions has been reported in some studies; while others show significant discrepancies (cf. Surwillo and Iyer, 1988; O'Donnell et al., 1990b). A single-tone paradigm described originally by McCarthy (1992) can also be used with uncooperative subjects. In this task, a target tone occurs randomly in time, just like in the 'oddball' paradigm, but the standard tone is replaced by silence and the subject is required to respond to every stimulus while only target tones are presented. Polich and McIsaac (1994) have compared this procedure directly with an active task, obtaining a similar pattern of P3 amplitude and latency (and N1, P2, and N2) in a population of 16 undergraduate students.

Because of its relationship to information processing, the P3 has been studied extensively across the lifespan in order to evaluate the neurophysiological basis of the changes in cognition that occur with ageing (Courchesne, 1978; Howard and Polich, 1985; Martín et al., 1988). Developmental and ageing studies have found that the relation between P3 latency and age allows me to establish regression lines and their standard deviation bands, which have been proposed as baseline criteria for detecting the presence of different types of cognitive dysfunction (Goodin et al., 1978b; Squires et al., 1980; Brown et al., 1982; Syndulko et al., 1982). Precise knowledge of the normal age/P3 latency regression function is critical to the determination of deviant latencies. Most P3 development studies have employed the oddball paradigm (Marsh and Thompson, 1972; Courchesne, 1978; Goodin et al., 1978a,b; Pfef ferbaum et al., 1980; Howard and Polich, 1985; Martín et al., 1988) while there are only a few reports about P3-like potentials obtained with passive procedures (O'Donnell et al., 1992; Fugichami et al., 1995).

As it has been observed, the effect of age for the P300 potential were strong while only small latency changes were found for the N1, P2, and N2 components (Goodin et al., 1978a; Polich, 1996). Concerning the N2 component, there is a general agreement that N2 latency increases with age to a lesser degree than P300 latency (Goodin et al., 1978b; Brown et al., 1983; Picton et al., 1984; Iragui et al., 1993). For the N1 components, most of the studies on age-related ERP changes found no significant effects of ageing on latency (Goodin et al., 1978a; Brown et al., 1983; Pfef ferbaum et al., 1984; Picton et al., 1984) and with regard to the standard tone P2 component, some authors reported a latency increase with advancing age, while others found no significant age-related changes of P2 latency (Goodin et al., 1978b; Picton et al., 1984; Iragui et al., 1993).

Only a few studies have reported the relationship between P300 topography and age (Goodin et al., 1978a; Picton et al., 1984; Iragui et al., 1993). These studies reported a shift to more frontally oriented and more equally distributed
P300 amplitude topography with increasing age. Several other authors have found shorter P300 latencies at Fz and/or Cz than at Pz (Patterson et al., 1988; Polich et al., 1996; Iragui et al., 1993). The shorter frontal latencies might result from the frontally distributed earlier P3a component overlapping the P3b wave. The lack of an interaction between age and electrode sites for P300 latency/age slopes is in accordance with the reported similar increase of P300 subcomponents latencies with advancing age (Polich et al., 1985; Knight, 1987; Friedman et al., 1993).

In the current study, we expected that there would be no differences between the amplitude and latency of the P3 and N1, P2 and N2 components elicited by the active and passive or single tone paradigm. However, since the demands of the attentional resources on the three tasks employed varies considerably, we expected that there could be differences in the scalp distributions of the ERP components. We assume that differences in scalp distributions reflect different generator configurations and hence differences in the cognitive underlying processes.

In the present study, we address three issues: (1) obtaining data about the latency, amplitude and morphological characteristics of the P3 component elicited with active, passive and single-tone paradigms in a well selected group of children; (2) making a direct comparison between the ERPs elicited with these three procedures in this study group; (3) whether the passive and single-tone paradigm as well as active P3 latency decreases with age.

2. Method

2.1. Subjects

Seventy-two subjects, aged from 6 to 14 years, participated in this experiment. The subjects were divided into three groups of 24 persons each: Group I: From 6 to 8 years old (M = 7.33, S.D. = 1.23); Group II: From 9 to 11 years old (M = 10.45, S.D. = 1.14); and Group III: From 12 to 14 years old (M = 12.57, S.D. = 0.76). There were equal numbers of boys and girls in each group.

The children were volunteers recruited from a local school. In all cases a written consent form was obtained from their parents to participate in this study. All subjects reported no neurological or psychiatric problems and their performance in their attending school task was adequate.

2.2. Recording conditions

Electroencephalographic (EEG) activity was recorded at the Fz, Cz and Pz electrode sites of the 10–20 system using gold-plated electrodes affixed with electrode paste and tape, referred to linked mastoids (A1–A2) with a forehead ground, and impedance at ≤ 10 kΩ. Electro-oculograms (EOGs) were recorded from electrodes above and below the right eye to detect artifacts produced by eye movement or blinking. The filter bandpass was 0.5–30 Hz (12-dB octave/slope). The EEG was digitized at 1.5 ms per point for 768 ms with a 75-ms prestimulus baseline. Waveforms were averaged on-line by a commercial signal, which also controlled the stimulus presentation and artifact rejection. Trials on which the EEG or EOG exceeded ± 45 µV were automatically rejected. Subjects were highly cooperative in all task conditions, which resulted in very few trials rejected due to artifactual responses. Rest periods were provided between task conditions, lasting as long as subjects considered necessary.

2.3. Procedures

2.3.1. Active discrimination task

A simple auditory 'oddball' paradigm was employed in a way that a continuous series of 1000 Hz standard tones were presented with a 2000-Hz target tones occurring randomly in 20% of the trials. The stimulus tones had the same physical characteristics and presentation rates as those used in the passive sequence procedure (see below). Subjects were instructed to move the index finger of their right hand whenever a target tone was perceived. A total of 20 artifact-free target tones was obtained.

2.3.2. Passive sequence paradigm

This was designed following the same criteria proposed by Polich (1989). On each trial, a series
of 10 stimulus tones (50-ms duration, 9.9 ms rise/fall, 60-dB SPL) were presented in a binaural way with stimuli occurring once every 2 s. The first six tones of the series were always 1000-Hz standard tones, with a 2000-Hz target presented randomly at either the 7th, 8th, 9th, or 10th tone position, and standard tones presented at the remaining non-target positions. The 10-tone sequence was followed by a silent interval of 6 s before the next series began. A total of 20 sequences were presented for each trial block, with an equal number of targets (i.e. five) occurring at the 7th, 8th, 9th, or 10th position. The subjects were instructed to listen to the tones without making a response.

2.3.3. Single-tone paradigm

Exactly the same procedures were employed as those used for the recording of the ‘oddball’ task except for a standard tone, which would normally occur when the subject heard nothing. All other aspects of the recording situation were identical to the oddball procedure.

Finally, all stimuli were presented while subjects kept their eyes closed. The passive task conditions were always presented first, with the ‘oddball’ or single-tone condition presented after the passive task conditions had been experienced. This procedure was adopted to avoid inducing a response to the target stimulus during the passive task, which may have occurred if the ‘oddball’ or single-tone had been presented initially.

2.4. Statistical evaluation

The Geisser and Greenhouse (1959) correction was applied to all the analyses of variance with repeated measures of factors. Wave forms from each electrode site and paradigm were analysed in the same fashion: the largest positive going peak occurring for all three electrode sites after the N1–P2–N2 complex between 250 and 400 ms was designated as the P3 component. Amplitude was measured in relation to the baseline, with the peak latency defined as the time point of maximum positive amplitude.

3. Results

The mean latencies and standard deviation of the P3 in the active, passive and single-tone paradigms, for the three age groups, are listed in Table 1. The highest variability in P3 latency was obtained in Group I for the passive, active and single-tone, while, an also high but less marked variability was observed in Group II for the active, single-tone and passive paradigms.

<table>
<thead>
<tr>
<th>Age group</th>
<th>5–8</th>
<th></th>
<th>9–11</th>
<th></th>
<th>12–14</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td><strong>Active</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pz</td>
<td>383.12</td>
<td>122.39</td>
<td>308.52</td>
<td>71.60</td>
<td>306.53</td>
</tr>
<tr>
<td>Cz</td>
<td>405.83</td>
<td>96.07</td>
<td>318.89</td>
<td>72.52</td>
<td>311.15</td>
</tr>
<tr>
<td>Fz</td>
<td>415.16</td>
<td>99.01</td>
<td>332.21</td>
<td>38.46</td>
<td>321.46</td>
</tr>
<tr>
<td><strong>Passive</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pz</td>
<td>425.81</td>
<td>90.52</td>
<td>327.93</td>
<td>49.63</td>
<td>293.38</td>
</tr>
<tr>
<td>Cz</td>
<td>433.16</td>
<td>96.40</td>
<td>332.14</td>
<td>42.66</td>
<td>301.93</td>
</tr>
<tr>
<td>Fz</td>
<td>445.72</td>
<td>93.88</td>
<td>339.77</td>
<td>38.84</td>
<td>313.68</td>
</tr>
<tr>
<td><strong>Single</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pz</td>
<td>406.56</td>
<td>80.92</td>
<td>292.79</td>
<td>43.44</td>
<td>296.93</td>
</tr>
<tr>
<td>Cz</td>
<td>411.02</td>
<td>82.63</td>
<td>311.93</td>
<td>60.29</td>
<td>304.40</td>
</tr>
<tr>
<td>Fz</td>
<td>416.50</td>
<td>83.29</td>
<td>310.66</td>
<td>53.21</td>
<td>328.87</td>
</tr>
</tbody>
</table>
Fig. 1. Superimposed grand average ERPs from each electrode site for each paradigm and subject age group.
Fig. 2. Mean P3 amplitude and latency from each paradigm and electrode site in all groups.
Fig. 1 displays the superimposed grand average for the target tones from each electrode site for each paradigm and for all the age groups. The feasibility of identifying the N1, P2, N2 and P3 varies according to the component and also in relationship to the age group. In this way, there is a better definition in the ERPs obtained for Group III for the active and passive paradigm.

A three-factor (paradigm $\times$ electrode $\times$ age group) analysis of variance was performed on the P3 latency and amplitude data from each subject. The P3 amplitude and latency means for each paradigm as a function of electrode site in all groups are illustrated in Fig. 2.

### 3.1. P3 latency

The strong decline across age group, for the three paradigms, was significant ($F_{2.69} = 40.83$, $P < 0.0001$). For each elicitation task, the usual overall decrease in latency from the frontal to parietal electrode site was obtained ($F_{2.68} = 17.32986$, $P < 0.0001$). No significant differences were obtained between the three paradigms in each age group. Hence, P3 latency did not differ in any systematic or reliable way from the 'oddball', passive and single-tone procedures. There was not age-related topographical effect.

In the oddball, passive and single-tone paradigms the P3 amplitude did not differ in general ($P < 0.05$). However, as indicated in Fig. 2, the elicitation task did produce variegated patterns for P3 amplitude as a function of age and electrode conditions. First, the paradigm used interacted with the electrode site and with the group of age such that the active paradigm yielded larger P3 amplitudes than the single-tone and passive paradigms for Group III at the vertex electrode position ($F_{1.69} = 11.88$, $P < 0.001$) and at the parietal electrode position ($F_{1.69} = 15.42$, $P < 0.0001$); the single-tone paradigm yielded the largest P3 amplitude for Group I at the frontal electrode position ($F_{1.69} = 7.83$, $P < 0.007$). Second, the single-tone paradigm yielded P3 components that were somewhat smaller than those obtained with the active and passive paradigms, ($F_{2.68} = 4.58281$, $P < 0.014$). This overall difference originated from an interaction between age group and paradigm. So in Group I and II similar P3 amplitudes for the three paradigms were obtained, whereas in Group III smaller P3 amplitudes for the single-tone paradigm were obtained compared with the other elicitation tasks ($F_{1.69} = 5.37$, $P < 0.023$). Third, the usual increase in P3 amplitude from the frontal to the parietal electrode site was also found ($F_{2.68} = 8.20652$, $P < 0.001$). The parietal electrode site yielded significantly larger P3 amplitudes for the active ($F_{1.69} = 28.11$, $P < 0.0001$) and passive paradigms ($F_{1.69} = 6.19$, $P < 0.015$). Thus, the three paradigms produced similar P3 amplitude patterns across the three age groups, although the single-tone paradigm demonstrated a more frontal scalp distribution.

### 3.2. N1, P2 and N2 components

The mean amplitudes, latencies and standard deviations of the N1, P2 and N2 components measured at the Cz electrode from the target stimuli for each paradigm are illustrated in Table 2 as a function of age group. Component values were assessed with a two-factor (paradigm $\times$ group) analysis of variance.

N1 amplitude was smaller for the single-tone paradigm than the passive and active paradigms ($F_{1.65} = 15.10$, $P < 0.0001$). No significant interaction between group and paradigm was found. P2 amplitude was larger for the single-tone paradigm than for the active and passive paradigm ($F_{1.69} = 14.01$, $P < 0.0001$). No significant interaction between group and paradigm was found. N2 amplitude showed a significant interaction between age group and paradigm ($F_{2.69} = 7.31$, $P < 0.0001$). The single-tone paradigm was larger than the active paradigm ($F_{1.69} = 6.44$, $P < 0.013$) and the passive paradigm was smaller than the active paradigm ($F_{1.69} = 31.00$, $P < 0.0001$) for the age Groups I and II. No differences between the three paradigms were found in age Group III.

N1 latency was shorter for the passive paradigm than for the ‘oddball’ paradigm ($F_{1.69} = 7.24$, $P < 0.009$) and the ‘oddball’ paradigm demonstrated shorter latencies than the single-tone paradigm ($F_{1.69} = 51.83$, $P < 0.0001$) for age Group I. For age groups II and III the single-tone paradigm...
Table 2
Mean (S.D.) N100, P200, and N200 amplitudes and latencies from the Cz electrode site for each paradigm

<table>
<thead>
<tr>
<th>Group</th>
<th>Amplitude (μV)</th>
<th>Latency (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N100</td>
<td>P200</td>
</tr>
<tr>
<td><strong>Group I</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td>-5.8 (7.3)</td>
<td>4.6 (4)</td>
</tr>
<tr>
<td>Passive</td>
<td>-6.1 (4.9)</td>
<td>5.4 (4)</td>
</tr>
<tr>
<td>Single</td>
<td>-8.8 (6.3)</td>
<td>6.6 (6.5)</td>
</tr>
<tr>
<td><strong>Group II</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td>-8.3 (6.9)</td>
<td>4.9 (8)</td>
</tr>
<tr>
<td>Passive</td>
<td>-8.2 (7.9)</td>
<td>5.1 (4.6)</td>
</tr>
<tr>
<td>Single</td>
<td>-11.2 (9.2)</td>
<td>10.7 (9.3)</td>
</tr>
<tr>
<td><strong>Group III</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td>-7.1 (6.2)</td>
<td>5.1 (6.2)</td>
</tr>
<tr>
<td>Passive</td>
<td>-7.9 (5.7)</td>
<td>3.6 (5.2)</td>
</tr>
<tr>
<td>Single</td>
<td>-11.9 (6.6)</td>
<td>10.3 (9.7)</td>
</tr>
</tbody>
</table>

was larger than the passive and active paradigms ($F_{2,69} = 7.94$, $P < 0.001$) as a result of an overall interaction between paradigm and age group ($F_{4,136} = 5.745$, $P < 0.0001$). P2 latency was shorter for the passive paradigm than for the ‘oddball’ paradigm for age Group I ($F_{1,69} = 32.37$, $P < 0.0001$) and II ($F_{1,69} = 7.60$, $P < 0.007$). The active and passive paradigms were shorter than the single-tone paradigm ($F_{2,69} = 3.29$, $P < 0.043$) in general. A significant interaction between paradigm and age groups was also found ($F_{4,136} = 4.94311$, $P < 0.001$). N2 latency was shorter for the passive paradigm than for the ‘oddball’ paradigm ($F_{1,69} = 6.44$, $P < 0.0001$) and the ‘oddball’ paradigm demonstrated shorter latencies than the single-tone paradigm ($F_{1,69} = 31.00$, $P < 0.0001$) for the age Groups I ($F_{2,68} = 10.20997$, $P < 0.0001$) and II ($F_{2,68} = 15.29336$, $P < 0.0001$). An overall interaction between paradigm and age group was also obtained ($F_{4,136} = 3.29844$, $P < 0.013$).

A linear correlation was obtained for the relationship between age and latencies and amplitudes of the ERP components (Table 3). P3 latency showed a significant correlation regardless of the age group, while P3 amplitude showed a positive significant correlation at Cz in the active paradigm; a negative significant correlation at the Pz electrode placement, in the passive procedure; and a negative significant correlation in the single-tone paradigm in each electrode site.

A scatterplot of the relationship between age and P3 latency is shown in Fig. 3. The usual decrease in latency values are observed as age increases regardless of the electrode position and the paradigm used. The correlation for the active paradigm was $-0.4641$ ($P < 0.001$), for the passive was $-0.6400$ ($P < 0.001$), and for the single-tone was $-0.5102$ ($P < 0.001$). The regression line for the active paradigm has a slope of $-15.12$ ms/year, for the passive $-22.09$ ms/year and for the single-tone $-15.69$ ms/year.

The effect of age and sex were evaluated with an ANOVA. This analysis showed no significant sex differences in the latency or amplitude of P3.

4. Discussion

The major purpose of the present study was to evaluate the ERPs obtained from childhood to adolescence from a classic oddball paradigm, a passive paradigm, which does not require an active task participation, and a single-tone paradigm where the subject is required to respond to every stimulus. Only a few studies have been reported in which P300 waves were obtained with a passive procedure since childhood (Polich, 1989;
Fig. 3. P3 latency scattergrams plotted from each electrode site and paradigm.
Table 3
Significance of linear trends for P3 latency and amplitude for the age subjects at each electrode site for each paradigm

<table>
<thead>
<tr>
<th></th>
<th>P3 latency</th>
<th></th>
<th>P3 amplitude</th>
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<tr>
<td></td>
<td>Intercept</td>
<td>Slope</td>
<td>Correlation</td>
<td>Intercept</td>
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<td>AGE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pz</td>
<td>471.987</td>
<td>−14.089</td>
<td>−0.372***</td>
<td>6.952</td>
</tr>
<tr>
<td>Cz</td>
<td>500.083</td>
<td>−15.788</td>
<td>−0.464***</td>
<td>3.845</td>
</tr>
<tr>
<td>Fz</td>
<td>505.027</td>
<td>−15.123</td>
<td>−0.489***</td>
<td>6.222</td>
</tr>
<tr>
<td>Passive</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pz</td>
<td>565.075</td>
<td>−22.013</td>
<td>−0.649***</td>
<td>14.255</td>
</tr>
<tr>
<td>Cz</td>
<td>572.579</td>
<td>−22.017</td>
<td>−0.640***</td>
<td>10.074</td>
</tr>
<tr>
<td>Fz</td>
<td>583.641</td>
<td>−22.287</td>
<td>−0.647***</td>
<td>8.074</td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pz</td>
<td>492.605</td>
<td>−15.806</td>
<td>−0.495***</td>
<td>15.371</td>
</tr>
<tr>
<td>Cz</td>
<td>506.803</td>
<td>−16.360</td>
<td>−0.512***</td>
<td>14.465</td>
</tr>
<tr>
<td>Fz</td>
<td>505.684</td>
<td>−15.993</td>
<td>−0.302***</td>
<td>15.538</td>
</tr>
</tbody>
</table>

*P < 0.05.  
***P < 0.001.

Fugichami et al., 1995) and no one has published the single-tone paradigm for this age group.

In general, the P3 components obtained in this research: (1) produced virtually identical peak latencies between the three paradigms applied to the age groups studied; (2) the active, passive and single-tone paradigms demonstrated comparable scalp distributions; and (3) a similar age effect was found over the ERP components elicited by the three paradigms: as age increased, P3 latency decreased regardless of the paradigm used.

The components N1, P2 and N2, showed significant differences in amplitude and latency between the three paradigms. The most consistent difference between the three paradigms was larger P2 values for the single-tone paradigm than for the passive and active paradigms. The difference in P2 may be explained, at least partly, as a result of the absence of the frequent stimuli in the single-tone paradigm.

4.1. Passive vs. active paradigms

In the present study, the passive and active conditions showed similar P3 latencies and scalp distributions. These results are consistent with those obtained in previous studies in which a similar passive paradigm was employed with children (Mclsaac and Polich, 1992; Fugichami et al., 1995) and also with adults (Polich, 1987, 1989; Polich and Mclsaac, 1994). In addition, the P300 obtained with a passive procedure, reproduced morphologically the waves obtained from the active discrimination task, as well as those observed under other task situations which did not require a direct response from the subject but did elicit an automatic assessment of stimulus changes (Courchesne, 1978; Courchesne et al., 1975; Squires et al., 1975; Polich, 1987, 1989). In this task situation the subject automatically assesses the stimulus presented by making the target tone very different compared to the standard stimulus. It is reasonable to suppose that the cognitive process involved in these paradigms reflect psychological process involved in an active discrimination task, since the ERPs obtained with both procedures are virtually identical. We suggest that these similarities reflect the same neural and cognitive mechanism for both task situations, and that the subjects 'update' their memories when the target tone is presented.
4.2. Single-tone vs. active paradigms

The results obtained in the present study, relative to the single-tone paradigm, show similar latencies and amplitudes to those obtained by the active and passive tasks. In addition, the morphology of the P300 obtained with the single-tone paradigm appears very similar to the ERPs obtained by other procedures where a P300 component is elicited by a 'novel' stimulus and where the experimental demands are more focused on the detection of stimuli rather than the categorisation process (e.g. Courchesne et al., 1975, 1984; Knight, 1984; Yamaguchi and Knight, 1991). The cognitive function attributed to these types of paradigms may reflect some aspects of the orienting response, a behavioural function in which the frontal lobes are thought to be involved (Luria, 1973).

4.3. Ageing effect

As age increases, the morphology and values of the ERPs were closer to those obtained in adults regardless of the paradigm used. P3 latency in the active task demonstrated a rapid (−15.788 ms/year) decrease as age increased in children. The results are consistent with those obtained by Martín et al. (1988) of −19 ms/year and in some degree, with other results that report longer P3 latencies in young children than in adolescents and adults (Courchesne, 1977, 1978, 1983; Goodin et al., 1978a; Finley et al., 1985; Barajas, 1991). The passive P3 latency also decreased as age increased (−22.017 ms/year), in agreement with previous studies done with children by Fugichami et al. (1995). As in the previous procedures, P3 latency from the single-tone paradigm demonstrated a rapid decrease as age increased (−16.36 ms/year). These findings suggest that the latency of the P3 response, elicited by the three paradigms employed in this study, may be prolonged by the same neurological factors.

5. Conclusions

According to the results of the present study, the single-tone and the passive auditory stimulus paradigm elicited P3 components comparable to a typical auditory oddball paradigm, from childhood to adolescence.

The P3 waves found in the present study may represent neural elements of a common cerebral mismatch detector underlaying the orienting response. The prolonged latency of the P300 from the active and passive paradigms relative to the P300 from the single tone paradigm, may be related to the the unposed decision processes required in identifying the stimulus as a target and subsequently orienting to it. The presentation of the target tone in the single tone paradigm would generate a P300 without the need of an intervening decision process of discrimination between the standard and the deviant tone.

The effect of age on these procedures behaved similarly regardless of the task employed; as age increased P3 latency decreased. The neural substrate underlying the age-related changes in P300 from the three paradigms is uncertain, although the fact that amplitude and latency for P300 undergo parallel changes with ageing suggests that these brain potentials may share elements of a common neural system.

The simplicity of the tasks involved in the ERP elicited by the passive and single-tone paradigms may indicate that the single-tone and the passive paradigms can constitute a useful way with which to obtain the P3-like component. In addition, the single-tone paradigm and the passive paradigm may be especially useful for applied or clinical situations in which conventional discrimination task procedures cannot be employed.

References


