EVENT-RELATED POTENTIALS ELICITED BY INFREQUENT NON-TARGET STIMULI IN YOUNG CHILDREN OF ALCOHOLICS: FAMILY HISTORY AND GENDER DIFFERENCES

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Event-related potentials elicited by infrequent non-target stimuli in young children of alcoholics: Family hisory and gender differences [1]

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ABSTRACT

This article analyses the visual and auditory event-related potentials (ERPs) elicited by infrequent non-target stimuli in young children with alcoholic fathers. The aim was to study the characteristics of the ERP waves specifically evoked by stimuli which capture the attention of the subject in young ones at risk for alcoholism, and to assess the effect of sample factors which can modulate these characteristics, namely family history of alcoholism and gender. There were no differences related to risk for alcoholism on the auditory ERPs. However, males and females with a multigenerational family history of alcoholism showed significant differences on visual ERP latencies, although different waves were affected for each gender. Females showed a larger latency of the visual frontal negative wave, Nc, and males showed a larger latency of the visual parietocentral P300 wave.

INTRODUCTION

The consideration that alcoholism is a heterogeneous and multifactorial disease, which concerns both aetiological and clinical characteristics, has led to the development of several strategies to approach the problem. Research on genetic epidemiology provided evidence that some subtypes of alcoholism run in families and that genetic factors have an important role in this family transmission (see Hesselbrock, 1995 for a review). These conclusions have contributed to the development of studies for high risk using children of alcoholics. These studies assess different psychobiological variables (biochemical, psychophysiological, neuropsychological, behavioural or personality variables) as potential markers for alcoholism, with the aim of identifying those subgroups of die population with an increased vulnerability to the disease (Sher, 1991; Begleiter and Kissin, 1995).

More than 10 years ago, Begleiter and coworkers reported that children of alcoholics showed reduced amplitudes of the event-related potentials (ERPs) P300 waves, even before they were exposed to alcohol (Begleiter et al., 1984). Since then, this wave has been considered one of the main candidates of phenotypic markers for risk for alcoholism [see Polich et al. (1994) and Begleiter and Porjesz (1995) for recent reviews]. The reduced amplitude and, to a lesser extent, the larger latency, of P300 seems to be associated with multigenerational alcoholism and appears to be more consistent in young subjects and to be related to difficulties in allocating the necessary attentional resources to the stimuli relevant for the task, or with difficulties in discriminating and assessing the significance of these stimuli.

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Therefore, assessment of ERPs is a special area of interest in research on vulnerability to alcoholism in human subjects. ERPs not only provide information about potential neurofunctional anomalies in healthy individuals, but also relate those neurofunctional characteristics to the cognitive processes involved. It is therefore of interest to study other ERP components which can provide information about aspects of information processing which are suspected to be disturbed in subjects at risk for alcoholism.

Attentional problems have traditionally been present in studies of children of alcoholics. They are frequently reported as subjects with attentional deficits and hyperactivity during childhood (Tarter, 1990). Some authors have found that such children achieve lower performance in neuropsychological attention tests (Tarter et al., 1989; Ozkaragoz and Noble, 1995; Ozkaragoz et al., 1997). Moreover, studies using psychophysiological autonomic measurements have described children of alcoholics as hyperreactive in response to novel stimulation, even when this is nonaversive, e.g. skin conductance during the orienting response (Finn et al., 1990). The psychobiological models of family vulnerability to alcoholism relate these characteristics to dysfunctions at fronto-mesencephalic structures (Tarter et al., 1990), or to difficulties in information processing involving the prefrontal cortex (Peterson and Pihl, 1990; Pihl and Peterson, 1991).

The present paper examines the electrophysiological response of young subjects to novel, or simply irrelevant, stimuli which interfere with the course of a discrimination task. The aim was to determine whether subjects at high risk for alcoholism show anomalies in the processing of distractor stimuli which could contribute to their difficulties in the processing of the relevant information. Studies with adult samples have reported that the effect of a distractor task on the ERPs recorded during an oddball paradigm was different for subjects at high risk and controls (Bauer et al., 1994). However, these authors have not assessed whether there were differences on the ERPs elicited by the distractor stimuli. On the other hand, in recent studies, it was considered of interest to include an infrequent non-target stimulus in the classical oddball paradigm, inorder to assess additional cognitive aspects related to processing of automatic stimuli (Katayama and Polich, I996a,b).

In the present research, both boys and girls were studied and children of alcoholics were alsodivided into two groups, according to the family history (FH) of alcoholism of their fathers. This allows the detection of potential gender differences and also differentiates between the contribution of genetic and environmental factors on ERP characteristics of children of alcoholics. Given that this research assesses a young sample, the special characteristics of the ERPs in childhood must be taken into consideration. Courchesne and coworkers have described the waveform of ERPs elicited by novel stimuli in children (Courchesne, 1977, 1978, 1983; Lincoln et al., 1987). At the range of latency of the adult frontal P300 (P3a), this waveform is characterized by a negative frontal wave, Nc, which is related to the categorization of attention-getting stimuli, and a parietocentral positivity, similar to the adult P300 (P3b). Courchesne has suggested that this different waveform indicates that the processing of novel events is less mature in children. The frontal Nc and parietocentral P300 waves are studied in this report along with FH of alcoholism, given that these waves may provide information about the proposed difference in developmental trajectories between children of alcoholics and control subjects (Polich et al., 1994).

SUBJECTS AND METHODS

Subjects

The total group of subjects (n = 101) comprised of 31 children of alcoholic fathers with a high density FH of alcoholism [high risk (HR) group] (17 boys and 14 girls), 34 children of alcoholic fathers with a negative FH of alcoholism [low risk (LR) group] (16 boys and 18 girls) and 36 control subjects, children of non-alcoholic fathers without a FH of alcoholism [control (CN) group] (17 boys and 19 girls). The age range was from 7 to 15 years. Children of alcoholics were identified at community treatment centres, where their fathers had been diagnosed and treated. All the alcoholic fathers met the DSM-III-R (American Psychiatric Association, 1987) criteria for alcohol dependence (diagnosis made by the staff of the centres and corroborated during the selection interview); those with a history of psychopathological problems other than secondary to alcoholism (according to clinical history from the centres and information collected during the selection interview) were excluded. Subjects were classified according to the FH of alcoholism, ascertained through fathers using the FH interview method. Children of alcoholics who had at least two other first- or second-degree relatives with alcoholism were included in the HR group. Children of alcoholics without other first- or second-degree affected relatives were included in the LR group; other cases were excluded. In order to select subjects within the same age-range and socioeconomic status as those in the risk groups, control subjects were recruited from voluntary families from schools in the region. Control families who reported any problems with alcohol in first- or second-degree relatives were excluded.

Other criteria for exclusion were similar for the three groups, and included consumption of alcohol or other drugs, a history of psychopathological disorders, prenatal exposure to alcohol, developmental or school retardation, a positive neurological history, major medical problems, current medication, non-corrected sensory deficits, a familial history of major mental diseases, and problems of maternal alcoholism. Information about inclusion and exclusion criteria was obtained through structured semi-interviews with both the children and their fathers and mothers. The interviews were a translated and adapted version of the Semi-Structured Assessment for the Genetics of Alcoholism (SSAGA), versions for adults, children, adolescents, and parents, as well as the Family History Assessment Module, designed by the Collaborative Study on the Genetics of Alcoholism (COGA) (Bucholz et al., 1994). Questions about individual and familial psychopathological problems were based on DSM-III-R and at least one other diagnostic classification system. Information was also obtained during the interviews about demographic data, familial relations, school achievement, and social activities.

The final sample was well matched for age (see Table 1) and education (all subjects were enrolled in compulsory schooling and were in the correct grade for that age) among the groups. The groups were matched as closely as possible for socioeconomic status and there were no differences in annual per capita income between the HR and CN groups (mean CN = 43504 ptas, HR = 35579 Spanish ptas, $p < 0.98$), although the LR group had lower incomes (mean LR = 31449 Spanish ptas, $p < 0.010$).

Procedure

Families who met the requirements of the study were asked to participate; those who agreed signed a consent form, and then received an appointment for assessment.

When children arrived at the laboratory (at 10:00 or 16:00), the members of staff showed them the laboratory and explained the contents and procedure of the assessment. Subjects from the three groups were equally distributed across several variables influencing the ERP measures (Polich and Kok, 1995), such as time of the assessment (month, hour of the day, $p < 0.749$), recency of food ingestion ($p < 0.838$) and handedness ($p < 0.598$). The presentation order of the tasks was the same for all the subjects, first the visual, then the auditory task.

This report includes the ERP waveforms recorded during the performance of two discrimination tasks, at visual and auditory modalities. Once electrodes had been put into place, subjects sat in a comfortable armchair in an electricallyisolated, sound- and light-attenuated laboratory. They received general instructions to avoid movements during the tests and to pay attention to the individual instructions before each test.

The visual discrimination task involved 280 stimuli, each with a duration of 100 ms and with a constant interstimuli interval of 1.7 s. Stimuli were presented using a video monitor placed 100 cm from the subjects' eyes, and subtended a visual area equal to 1.7° x 1.7°. Subjects were asked to identify the target stimulus, a white X, and to press a button with the dominant hand as soon as possible. Targets appeared with a probability of 0.125, inserted between standard stimuli (white squares). The series contained other randomly inserted stimuli, unequal geometric coloured figures with a global probability of 0.125, which acted as distractors.

The auditory discrimination task involved 200 pure tones, 90 dB SPL, of 50 ms duration (0.1 ms rise and fall time), with an interstimuli interval of 1100 ± 100 ms. Subjects had to detect the target (2000 Hz) and to press a button with the dominant hand when it appeared. Targets with a global probability of 0.15 were inserted randomly between standard (1000 Hz) tones; the sequence also contained infrequent non-target stimuli (500 Hz) with a global probability of 0.15.

ERP Recording

Electroencephalographic (EEG) activity was recorded at 20 scalp sites of the 10-20 system (Fp1, Fp2, Fz, F3, F4, F7, F8, Cz, C3, C4, Pz, P3, P4, Oz, O1, O2, T3, T4, T5, T6), using tin electrodes inserted in an electrocap (Electro-Cap International, Inc.), referred to linked earlobes and with a forehead ground. Additional electrodes were used to monitor eye movements (supraorbital and the outer canthus of the left eye referred to an infraorbital electrode).

EEG activity was filtered (0.1-30 Hz) and amplified 10 K (Grass Neurodata Acquisition System, model 12, connected to a Neuro Scan, Inc. system for analogue-to-digital conversion and storage). Impedance values were kept at 5 kΩ or below.

EEG was sampled continuously at a rate of 256 Hz. The signal was processed off-line, first the EEG was corrected for vertical ocular movements, using the algorithm developed by Semlitsch et al. (1986) and then the EEG was epoched from 100 ms pre-stimulus to 900 ms post-stimulus, linear detrends were eliminated and the signal was adjusted to 0 uV pre-stimulus baseline. Trials affected by electromyographic activity or other artefacts (±90 uV) were identified by visual inspection and then rejected. Finally, trials were averaged according to the type of stimuli (210 standards, 35 targets, and 35 infrequent nontargets in the visual task; 140 standards, 30 targets, and 30 infrequent non-targets in the auditory task).

Data Analysis

ERP waves at the frontal electrodes Fz, F3, and F4, the central electrode Cz, and the parietal electrode Pz obtained from the infrequent nontarget stimuli were selected for this report. ERP components were identified by a double procedure. First, using a computer algorithm which searched from the maximum/minimum peak amplitude for each component with predefined latency windows; peaks were then verified and adjusted by visual inspection. Marks which were doubtful were re-marked by a second experienced member of the laboratory, blind to the classification of the case and to the initial mark. Amplitude and latency values were automatically exported to an ASCII file for subsequent analyses.

The Nc waves were identified at the frontal leads using latency windows of 240-500 ms in the visual modality and 175-400 ms in the auditory modality, and P300 waves at the central and the parietal leads using latency windows of 300-500 ms in the visual modality and 250-400 ms in the auditory modality.

Data from males and females were analysed separately. First, multivariate analysis of covariance with age as a covariate (MANCOVA, SPSS for Windows, version 6.0.1) was used to assess group (CN vs LR vs HR) differences on Nc latency and amplitude at the frontal electrodes, and on P300 latency and amplitude at the parietal and central leads from both the visual and the auditory records. Univariate analysis of covariance (ANCOVA) was used to analyse differences on Nc and P300 waves for individual electrodes between the three risk groups. A posteriori contrasts with significant levels revised using Bonferroni confidence intervals were performed where the main effect of risk group (RG) factor was significant ($p < 0.05$). Second analyses comparing only the CN and HR groups were performed using similar MANCOVA and ANCOVA procedures for frontal Nc and centroparietal P300 waves respectively.

RESULTS

From the 101 total subjects who participated in the research, waveforms corresponding to 91 subjects at the visual recordings (33 CN, 29 LR, 29 HR) and to 88 subjects at the auditory recordings (32 CN, 30 LR, 26 HR) were valid. The dropouts were caused by noise in the EEG records (due to body and horizontal ocular movements), by the inability to identify some of the ERP components (three cases), or by interruption of the recording because of subjects' fatigue or technical problems (two cases). Behavioural data (RT and percentage of omission errors) were compared using a one-factor ANOVA (risk group) and there were no differences between the three risk groups. Descriptive data and results from this analysis are summarized in Table 2.

Descriptive data of the visual and auditory measurements are summarized in Tables 3 and 4 respectively. Figures 1 and 2 show the grand-averaged waveforms from each risk group and gender from visual and auditory tasks respectively.

Frontal Nc waves

The MANCOVA analyses of the Nc wave characteristics in the infrequent non-target condition showed no significant differences among male risk groups for amplitude or

latency for either the visual or auditory recordings. However, females showed significant differences among groups on Nc latency for both the visual [$F(6,76) = 2.87$, $p < 0.014$] and the auditory [$F(6,76) = 3.62$, $p < 0.003$] modalities, and also on Nc amplitude for the visual recording [$F(6,76) - 2.64$, $p < 0.022$]. Univariate analyses of Nc from individual leads showed only significant risk group differences for females on visual Nc latency recorded at F3 [$F(2,40) = 4.82$, $p < 0.013$] and F4 [$F(2,40) = 4.05$, $p < 0.025$], where HR females showed larger latencies (Fig. 3). The covariate (age) was significant at the multivariate analyses on the auditory Nc amplitude for both males ($p < 0.001$) and females ($p < 0.001$).

Control vs High Risk groups. The MANCOVA analyses comparing only the CN and HR groups confirmed the lack of significant differences between these extreme risk groups for males. Differences remained significant for females on Nc latency for the visual [$F(3,25) = 4.10$, $p < 0.017$] and the auditory [$F(3,24) = 3.01$, $p < 0.050$] modalities. Univariate analyses showed that larger visual Nc latencies for the HR females remained significant at F3 [$F(1,27) = 4.22$, $p < 0.050$] and F4 [$F(1,27) = 4.86$, $p < 0.036$].

Parietocentral P300 waves

The MANCOVA analyses of the amplitude and latency of P300 waves showed no significant differences among male or female risk groups for either the auditory or the visual modalities. However, the ANCOVA analyses showed significant differences on the visual P300 latency at Pz [$F(2,37) = 3.55$, $p < 0.039$] for males (Fig. 4). The covariate (age) was significant at the multivariate analyses on the auditory P300 amplitude for males ($p < 0.004$) and females ($P < 0.001$), on the auditory P300 latency for males ($p < 0.028$), and on the visual P300 latency for males ($p < 0.003$) and females ($p < 0.001$).

Control vs High Risk groups. Multivariate analyses including only the CN and the HR groups showed that differences between the risk groups were not significant for females. However, risk group differences were significant on the visual P3 latency for males [$F(2,23) = 4.60$, $p < 0.021$]. The univariate approach confirmed the presence of larger visual P3 latency for HR males both at Pz [$F(l,24) = 7.44$, $p < 0.012$] and at Cz [$F(l,24) = 4.40$, $p < 0.047$].

DISCUSSION

The assessment of the ERPs elicited by infrequent non-target stimuli indicated that there were differences between young children of alcoholics and control subjects, which mainly affected the subjects with a multigenerational FH of alcoholism. The differences appeared on the latency measurements in the visual modality and the separate analyses for males and females showed that they affected different components in each gender.

The finding of anomalous values for the HR group on the visual ERPs is in accordance with the results of the meta-analysis of the P300 studies on males at risk for alcoholism published by Polich et al. (1994). These authors concluded that the visual ERP paradigms were more sensitive to differences between risk groups. On the other hand, the visual and the auditory infrequent non-target stimuli used in the present study were

not fully equivalent. While at the visual modality the stimuli were all different from each other, at the auditory modality the same irrelevant stimulus was repeated. It is therefore possible that our failure to observe differences between the risk groups in the auditory recordings was due to a decrease in the novelty of the stimulus throughout the task.

When only the CN and HR groups were compared, males showed a clearer effect of the risk group factor. At this level of analysis, delays on the visual P300 latency in the HR group were significant for both the parietal and central leads. This finding could be interpreted as an indication that high risk subjects needed more time to assess the significance of the infrequent non-target stimuli and to solve the uncertainty. Although P300 target studies with non-alcoholic high risk subjects have more frequently found differences on amplitude, delays on latency have also been reported (Whipple and Noble, 1986; Steinhauer et al, 1987; Whipple et al., 1991; Keenan et al, 1997), have been proposed as a good predictor of adolescent drug use (Berman et al., 1993), and they have been associated with the presence of the AI allele of the D2 dopamine receptor gene (Noble et al., 1994). Moreover, the findings presented in this report probably reflect the proposal of Katayama and Polich (1996a) that the latency of P300 elicited by the infrequent non-target events provides additional information about stimuli processing and could be a useful parameter in clinical studies.

As some of the multivariate significant results were not confirmed by the univariate approach, the results for females were not clear when the three risk groups were compared. However, the more consistent differences, those affecting the visual Nc latency, were further confirmed when only the CN and the HR groups were compared. HR females showed a significant delay on the visual Nc latency at the two lateral leads. Females with a FH of alcoholism have been frequently excluded from high risk studies. Therefore, their ERP responses are not well characterized, and the few reports assessing the two genders have found a less clear ERP pattern for females at risk (Hill and Steinhauer, 1993; Steinhauer and Hill, 1993). According to the functional significance attributed to the frontal Nc by Courchesne, HR females in this study needed more time to categorize the attention-getting uncategorized events. However, this was not accompanied with a delay in encoding the events (solving the uncertainty), as reflected by the centroparietal P300.

Finally, the differences between risk groups observed on the ERPs elicited from the infrequent non-target stimuli partially confirmed those showed by the target ERPs in the same sample (Rodriguez Holguin et al., 1998). In the two conditions, the strong differences involved the HR group and were observed in the visual modality and in the latency measures, although the P3b (target) differences only appeared in the female subsample, which also showed reduced visual P3b and delayed auditory P3b.

In summary, this research found that young subjects at high risk for alcoholism without personal or FH of another psychopathology, showed anomalies in their electrophysiological responses to infrequent novel stimuli during the course of a visual discrimination task. Both males and females showed anomalies in the ERPs, but they were specific for each gender. The pattern of ERP responses suggested that children at high risk for alcoholism took more time than controls to process novel information. The findings presented here point to the relevance of assessing those components of the ERPs related to the mode of information processing during childhood in the high risk studies. Finally, we should like to point out that, as far as we could ascertain, this is

the first report analysing the ERPs elicited by this kind of stimulus in young children of alcoholics. Therefore, the results must be considered with caution and need further replication in other laboratories using the same type of paradigm.

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Tables

Table 1. Demographic variables of the sample.

	Control		Low risk		High risk		Risk group differences (*P*)	
	Males $n = 17$	Females $n = 19$	Males $n = 16$	Females $n = 18$	Males $n = 17$	Females $n = 14$	Males	Females
Age (range)	8–15	8–15	7–14	8–15	7–15	7–15		
Mean (SD)	10.65 (2.18)	11.42 (2.41)	10.69 (2.52)	11.44 (2.25)	11.00 (2.33)	11.57 (2.53)	0.888	0.983
Grade level	4.94 (2.19)	5.58 (2.19)	5.50 (2.63)	6.11 (2.30)	5.72 (2.24)	6.36 (2.37)	0.607	0.601
Handedness (R/L/A)	14/2/1	18/1/0	16/0/0	17/0/1	16/1/1	12/1/1	0.532*	0.647*

*χ^2 comparison.

Table 2. Visual and auditory task performance among the study groups.

Variable		Control	Low risk	High risk	*F*	df	*P*
Visual	RT (ms)	460.95 (73.52)	480.28 (79.34)	452.43 (72.96)	1.15	2,92	0.321
	Per cent error	1.6	1.4	1.7	0.18	2,92	0.835
Auditory	RT (ms)	463.10 (93.76)	477.81 (100.73)	465.06 (110.38)	0.16	2,84	0.848
	Per cent error	7.4	8.4	10.2	0.43	2,84	0.647

Response time (RT) (means with SD in parentheses) and per cent of omission errors are given for both modalities and ANOVA comparisons between groups are shown.

Table 3. Visual Nc and P300 amplitudes and latencies (mean and SD) elicited by infrequent non-target stimuli for males and females of the control and the two risk groups.

		Control				Low risk				High risk			
		Amplitude (μV)		Latency (ms)		Amplitude (μV)		Latency (ms)		Amplitude (μV)		Latency (ms)	
Wave	Electrode	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Nc	Fz	−8.61	−11.46	354.96	326.13	−11.41	−6.79	363.93	314.20	−10.67	−10.70	351.90	349.82
		(6.36)	(4.93)	(73.87)	(42.47)	(8.90)	(6.14)	(74.40)	(26.80)	(6.13)	(7.87)	(50.61)	(42.19)
	F3	−6.68	−8.73	357.52	328.42	−10.65	−6.98	364.71	316.29	−10.17	−10.11	354.10	362.14
		(6.96)	(7.78)	(69.78)	(41.20)	(7.14)	(6.04)	(73.11)	(28.01)	(6.91)	(7.38)	(50.76)	(45.29)
	F4	−7.53	−10.13	352.64	323.94	−10.89	−7.87	364.32	317.27	−10.92	−10.59	350.68	357.33
		(6.29)	(4.87)	(70.76)	(35.42)	(8.37)	(6.44)	(77.06)	(35.63)	(7.48)	(8.49)	(55.00)	(45.03)
P300	Cz	7.68	2.22	396.68	418.70	8.02	5.04	412.94	420.26	4.16	2.01	424.49	431.13
		(7.11)	(7.47)	(69.48)	(35.81)	(7.37)	(6.41)	(39.64)	(56.70)	(7.09)	(8.47)	(54.17)	(48.62)
	Pz	11.70	8.92	387.92	425.83	11.04	9.87	418.08	426.20	11.53	8.25	438.54	433.27
		(7.43)	(8.09)	(63.43)	(38.38)	(4.82)	(6.23)	(58.04)	(50.72)	(5.95)	(4.96)	(49.09)	(59.41)

Table 4. Auditory Nc and P300 amplitudes and latencies (mean and SD) elicited by infrequent non-target stimuli for males and females of the control and the two risk groups.

		Control				Low risk				High risk			
		Amplitude (μV)		Latency (ms)		Amplitude (μV)		Latency (ms)		Amplitude (μV)		Latency (ms)	
Wave	Electrode	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Nc	Fz	−12.15	−16.18	256.86	260.89	−15.90	−12.96	254.56	260.81	−12.18	−12.18	271.35	275.35
		(6.23)	(7.21)	(31.04)	(27.98)	(5.63)	(6.54)	(25.69)	(22.93)	(7.30)	(6.79)	(24.54)	(25.40)
	F3	−12.11	−15.77	259.37	258.51	−17.85	−14.04	257.55	262.89	−11.81	−12.61	268.10	265.59
		(6.42)	(7.20)	(34.93)	(29.89)	(8.03)	(6.29)	(29.20)	(23.14)	(6.88)	(5.90)	(17.64)	(27.13)
	F4	−12.57	−17.21	259.65	260.89	−16.44	−13.95	253.91	256.77	−13.72	−13.15	266.41	276.24
		(5.64)	(7.63)	(34.86)	(23.78)	(6.82)	(7.11)	(25.38)	(24.69)	(9.49)	(6.81)	(23.27)	(21.44)
P300	Cz	3.03	4.93	341.18	333.06	2.36	5.17	332.99	349.17	2.86	2.15	348.33	361.64
		(5.98)	(11.40)	(42.94)	(38.24)	(9.44)	(6.82)	(29.93)	(26.61)	(8.07)	(8.09)	(27.29)	(49.55)
	Pz	6.15	8.92	337.56	335.74	3.97	11.96	341.96	351.06	8.19	4.91	347.77	354.47
		(4.48)	(8.92)	(42.68)	(29.55)	(6.75)	(6.07)	(29.93)	(21.53)	(6.95)	(11.48)	(24.49)	(33.55)

Figures

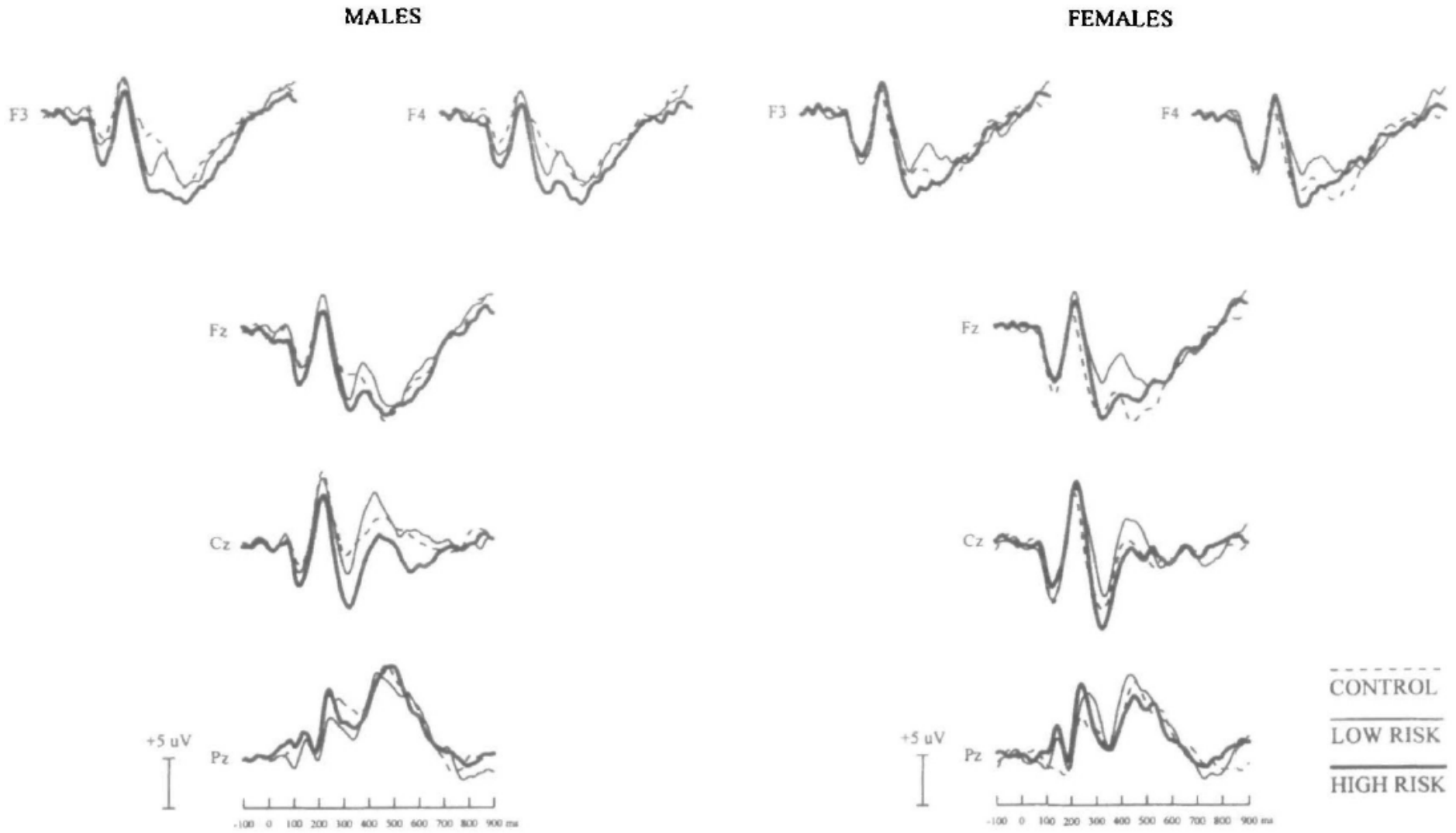

Fig. 1. Grand-averaged ERP waveforms elicited by visual infrequent non-target stimuli from control, low risk, and high risk males and females.

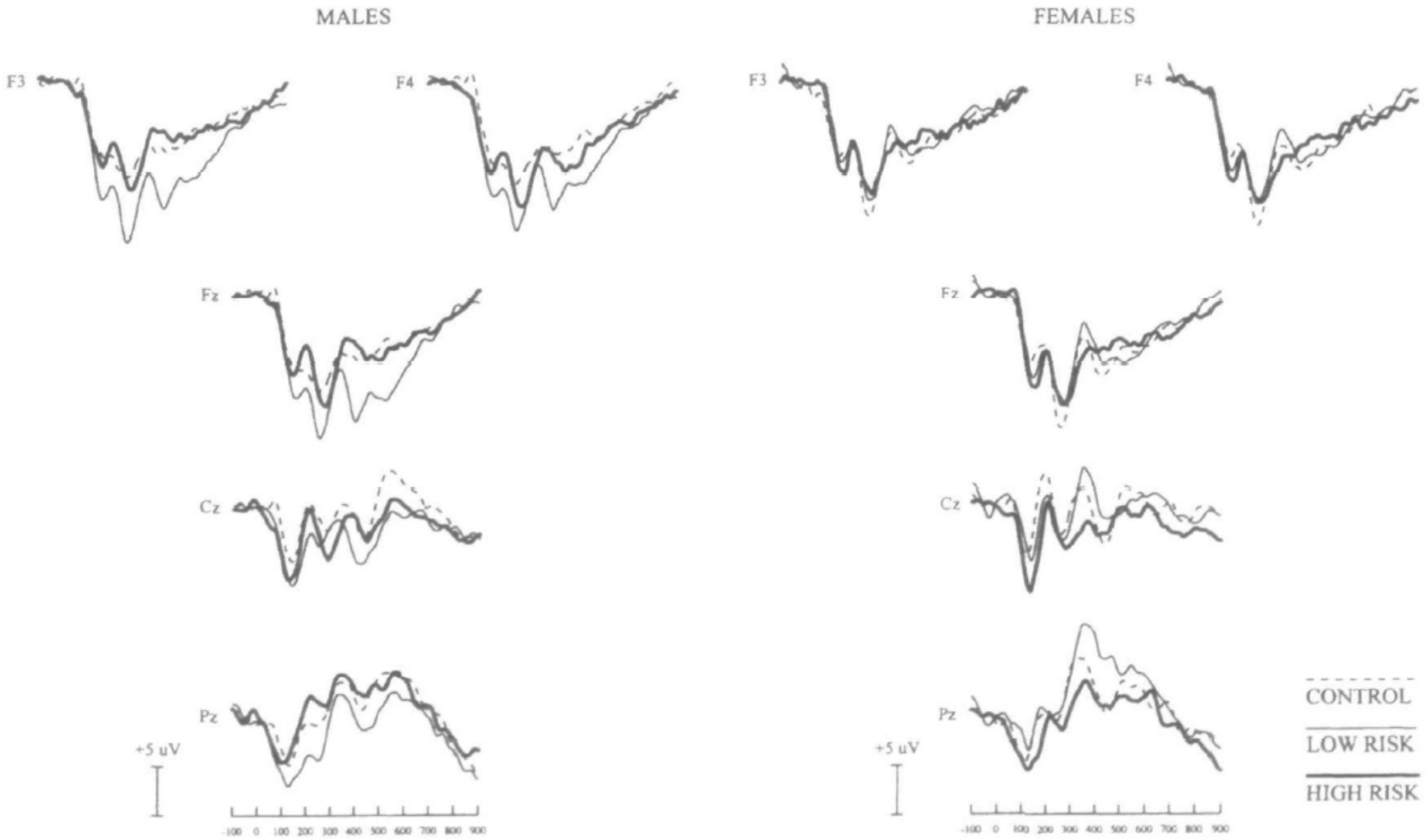

Fig. 2. Grand-averaged ERP waveforms elicited by auditory infrequent non-target stimuli from control, low risk, and high risk males and females.

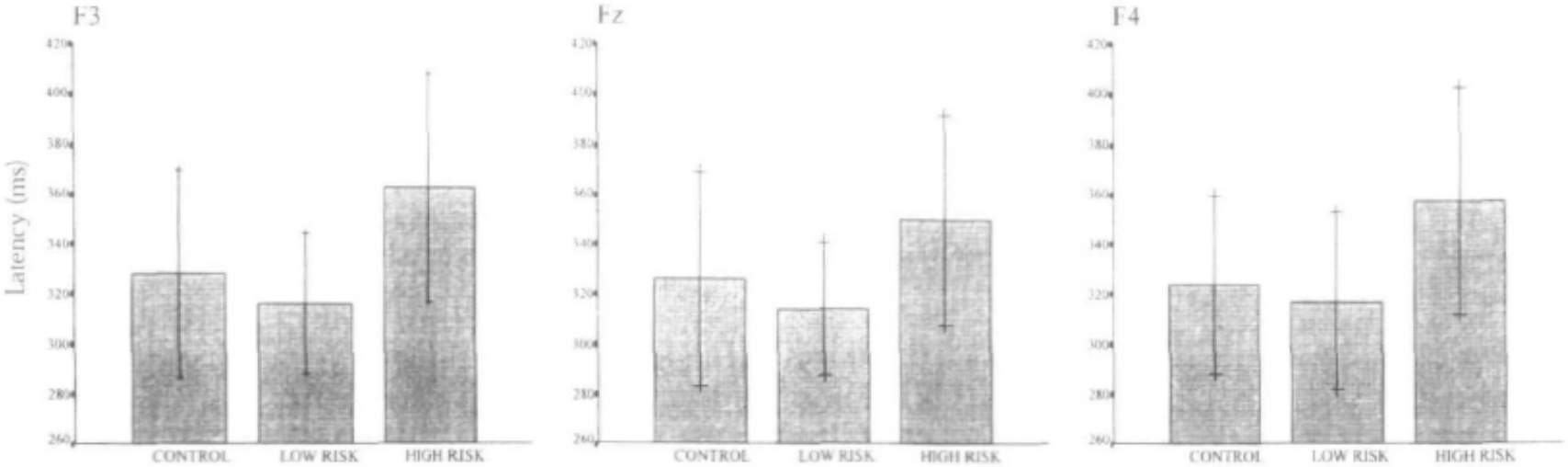

Fig. 3. Mean Nc latencies from the visual infrequent non-target stimuli for females in the control, low risk, and high risk groups.

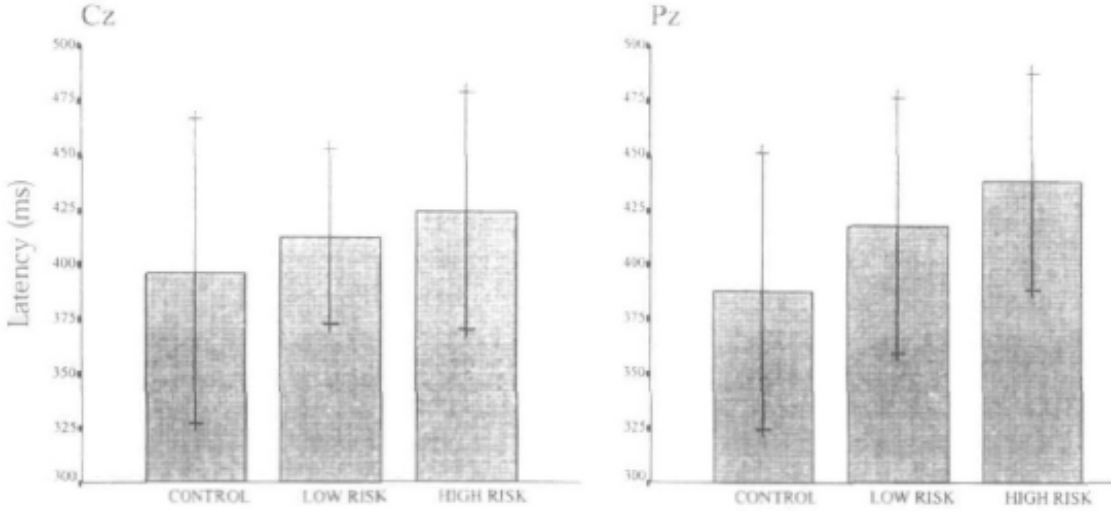

Fig. 4. Mean P300 latencies from the visual infrequent non-target stimuli for females in the control, low risk, and high risk groups.