CLINICAL, PSYCHOPHYSIOLOGIC, AND NEUROLOGIC CHARACTERISTICS OF VOLUNTEERS WITH IMPAIRED SMOOTH PURSUIT EYE MOVEMENTS

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In the last decade a renewed interest in dysfunctional smooth pursuit eye movements (SPEM) as a potential biologic marker for schizophrenia has been initiated largely by the work of Holzman and colleagues (1971,1978,1984). Their studies, which have been now consistently replicated by numerous other independent investigative groups (for review see Lipton et al., 1983), convincingly demonstrate that dysfunction in the smooth pursuit system can be observed in from 51-86% of schizophrenics, and one half of their relatives (Holzman et al, 1974,1978,1984), but is infrequently observed in the general population (Holzman et al., 1974). Impairment of the smooth pursuit system appears to reflect an underlying genetic alteration as it is observed about twice as frequently in monozygotic twins as it is in dizygotic twins (Holzman). It is also observed more frequently in the relatives of schizophrenics than in those of bipolar patients (Holzman et al, 1984). It has been hypothesized to represent a deficiency in nonvoluntary attention or "cognitive centering." (Holzman et al), that may be attributable to a neurointegrative defect, perhaps in the frontal lobes (Levin, 1984).

Recently we have reported that disordered SPEM may also be associated with the DSM-III diagnosis of Schizotypal Personality Disorder (SPD) (Siever et al, 1984), a disorder more frequently observed in the relatives of schizophrenics than in those of controls (Kendler et al., 1982; Gunderson et al., 1983), in a study utilizing the biochemical "high risk" strategy (Buchsbaum et al, 19). This strategy has the power to evaluate the relationship between a biologic variable and clinical characteristics without the confounding effects of previous course of illness, hospitalization or prior treatment. Additionally it has the advantage of avoiding the problem of heterogeneity in psychiatric illness, which may weaken studies of groups selected by membership in a particular diagnostic category. If the biological variable has a robust

association with a psychiatric illness, psychopathology related to the illness should be observed in a significant proportion of the individuals carrying the biologic "marker". We have reported a greater prevalence of SPD in individuals with SPEM impairment than in subjects from the same population with highly accurate SPEM, lending support to hypotheses that SPD may be genetically related to schizophrenia and that SPEM impairment may be an indicator of genetic factors predisposing to schizophrenia and related disorders (Siever et al., 1984).

However, in order to better understand the relationship between SPEM impairment and SPD, several questions remain to be answered: 1) what are the specific clinical characteristics of volunteer subjects with SPEM dysfunction? 2) are there other clinical or demographic variables that may account for this association? and 3) is impaired SPEM associated in this volunteer population with other psychobiologic and neurologic abnormalities observed in schizophrenics? and 4) what information do these relationships contribute to our understanding of the psychobiologic vulnerabilities associated with SPEM dysfunction?

With regard to the first question, accumulating evidence raises the possibility that characteristics such as social isolation, flattened affect and poor rapport may be more reflective of a genetic relationship to schizophrenia than psychoticlike symptoms such as magical thinking or recurrent illusions (Gunderson et al, 1983; Kendler et al, 1983,1984; Torgerson et al, 1984, in press; Siever et al, 1983,1985). Thus it is of interest to determine which of the individual schizotypal characteristics identified in DSM-III or in other diagnostic schema are most strongly associated with impaired SPEM.

It is also conceivable that differences in demographic or clinical variables such as age, family income and occupational status, education, drug or

alcohol usage, cigarette or coffee use, social history, and familial medical history may be related to the association between SPEM dysfunction and SPD. Thus, these variables were evaluated in relation to accuracy of SPEM.

Finally, abnormalities in accuracy on the continuous performance task (CPT) (Mirsky et al,), reaction time to specific stimuli (Zahn, 19); basal electroencephalograph (EEG) and average evoked potentials (AER) (Buchsbaum, 19); and neurologic soft signs (Wyatt et al., 19) have been reported in schizophrenics but have rarely been examined in schizotypal subjects. Would SPEM impairment be associated in our volunteer population with any of these other reported psychophysiologic abnormalities, some of which also are interpreted as reflecting an attentional impairment?

In order to critically examine these questions, we screened 285 male college student volunteers for accuracy of SPEM electroculographically and selected individuals with the most and least accurate SPEM (Siever et al, 1984). These individuals were then recalled for an extensive clinical evaluation, focusing on clinical characteristics thought to be associated with schizophrenia, by one of us (LJS), who was unaware of the subjects' eye tracking performance. These subjects were also evaluated psychophysiologically and neurologically utilizing measures of reaction time, continuous performance task errors, electroencephalogram (EEG), and auditory and visual average evoked responses (AER). We report here the relationship between SPEM impairment and specific clinical, demographic and epidemiologic variables as well as between SPEM accuracy and psychophysiologic and neurologic characteristics in this selected volunteer population.

Methods

Two hundred eighty-five subjects were recruited with a modest financial reimbursement from a local junior college for a brief on-campus electroculographic screening of eye tracking accuracy in following a swinging pendulum

exactly as described elsewhere (Siever et al, 1982,1984). All subjects signed an informed consent after a full explanation of the procedures with an understanding that they might be recalled for further testing at the National Institute of Mental Health.

Qualitative ratings of the electroculographic records using the method of Shagass (1974) provided the basis of selection criteria for the high and low accuracy tracking groups, as they correlate highly with more quantitative assessments of tracking accuracy (Lindsey et al., 19). The low accuracy trackers were those subjects in our screened sample with a mean qualitative rating greater than 3.0, all individual trials greater than 3.0, and marked impairment (>4.5) of at least one trial using the qualitative rating scale of Shegass (Shagass et al., 19) exactly as described and discussed elsewhere (Siever et al, 1984). This degree of tracking inaccuracy is comparable to that observed in schizophrenics (Siever et al, 1984). High accuracy trackers were those subjects with a mean qualitative rating of less than or equal to 1.5 and no qualitative rating of greater than 2.0 on any of the trials.

Thirty-one (mean age 23 ± 5) of the 34 low accuracy and 20 (mean age 23 ± 3) of the 22 high accuracy trackers selected by these criteria agreed to further testing at the National Institute of Mental Health (NIMH). All subjects participated in an extensive clinical interview conducted by one of us (LJS or ISA) unaware of the eye-tracking status of the subject. The interview included the Schedule for Affective Disorders and Schizophrenia Lifetime Version (SADS-L) (Spitzer et al., 19), the Family Study Interview from the NIMH Clinical Unit in Psychogenetics (Gershon et al., 19), and a more comprehensive semi-structured clinical interview with standardized questions (available on request from authors). All SADS were reviewed by a psychiatrist (LJS) after meeting with the subject. The semi-structured interview was based on a broad

questionaire which was designed to elicit information with regard to the individual's work, school, activities, social and family relationships, somatic function, impulse/action patterns, affects and cognitive-perceptual processes. The answers to these questions provided the basis for scoring a rating scale of characteristics accociated with either schizotypal or borderline personality disorder (Gunderson et al, 1982).

Thirty-four of the 51 volunteers were evaluated thoroughly by an experienced neurologist utilizing a neurologic exam focusing on "soft signs" (Peters et al, 1975) adapted for this study. A research electroencephalograph (EEG) and brain stem auditory and visual evoked potentials (Sato, 19 ; Bernad or Brady, 19) were also obtained on 33 of the subjects.

Thirty-five of the 51 volunteers were evaluated by the continuous performance task exactly as published elsewhere (Haier et al,). Subjects viewed a screen which displayed sequences of random numerals (Buchsbaum fill in).

Twenty-three individuals completed a reaction time battery ( ) based on a modification of techniques which have distinguished schizophrenic from control subjects (Zahn fill in).

Twenty subjects had 10 cc blood samples drawn for determination of platelet and plasma monoamine oxidase activity and dopamine beta hydroxylase actovity samples were separated into a platelet rich plasma fraction (Murphy et al., 19).

Thirty-eight of the original 51 volunteers were retested in the laboratory employing both an infrared and electro-oculographic (EOG) evaluations of tracking accuracy in order to validate our on-site screening procedures. All subjects were strictly instructed to avoid all alcohol or drug use for at least 24 hours prior to the reevaluation of SPEM accuracy. The EOG recordings were scored exactly as they had been on the initial screening and the identical

criteria were reapplied. Of the original 31 low accuracy trackers, 13 of the 27 available for retesting satisfied our selection criteria for low accuracy tracking under the controlled laboratory retesting. Segments of their tracking records are published elsewhere (Siever et al, 1984).

The infrared tracking apparatus utilized in the laboratory retesting monitored SPEM with photocell detection of reflected infrared light from the pupil, avoiding possible confounding bioelectric artifacts (Iacono et al., 1982). The photocell signal was amplified and recorded on a frequency-modulated tape recorder and analyzed by an electronic frequency analyzer courtesy of Dr. Philip Holzman. The frequency analyzer compares the power of the eye tracking signal at the target frequency, i.e., the "signal", and the power of the distortions of the signal at higher frequencies, i.e. the "noise" (Lipton et al, 1980). The greater the natural log of this ratio, i.e., the log of the signal-to-noise ratio (ln S/N), the more accurate is the tracking of the target.

These parameters were compared by Student's t-test between the initially screened low accuracy trackers (n=19) and high accuracy trackers (n=31) and between the laboratory confirmed low accuracy trackers (n=13) and high accuracy trackers (n=31), although the latter comparisons are the more relevant and for the most part will be reported here. Correlation coefficients were evaluated by the Pearson product-moment correlation for the combined groups between the demographic, clinical, and biologic variables and SPEM accuracy as measured electroculographically and scored qualitatively in the original screening and as measured by infrared detection and frequency analysis.

Results

The confirmed low accuracy trackers and high accuracy trackers were comparable on a variety of demographic variables. The mean age of the confirmed low

accuracy trackers was 25 ± 6 years and of the high accuracy trackers was 23 ± 3 years. Income, years of education, highest occupational level, military service and religion were not significantly different between groups. Parental income and education were also not different between the two groups. The confirmed low accuracy trackers included significantly more married subjects than did the high accuracy trackers ($p<0.05$). Confirmed low accuracy trackers were significantly less likely to have been arrested ($p<0.05$), convicted ($p<0.005$), or jailed ($p<0.05$) than the high accuracy trackers.

There were no significant differences between the two groups with regard to history of childhood systemic illnesses including asthma, epilepsy, diabetes, endocrine diseases; in history of childhood convulsions, high fever or head trauma, or in past hospitalizations. Family history of medical illnesses for the two groups were not significantly different except that the confirmed low accuracy trackers were more likely to have a family history of high blood pressure ($p<0.05$). Average alcohol intake and average number of cigarettes smoked per day were both significantly greater ($p<0.05$) in the high accuracy tracking group. No significant differences were observed between the two groups in self-reported anxiety on the test day, self report of sleep the night before the test, drug or alcohol use in days prior to the test.

As rated on the rating scale of borderline and schizotypal characteristics (Gunderson et al, 1983), low accuracy trackers were significantly different fro high accuracy trackers in a number of specific characteristics reflecting inter personal impairment, affective impoverishment, attentional disturbance and cognitive distortions (Table I). Impulsive features such as suicidal gestures, substance abuse, and antisocial acts, or affective symptoms such as affective lability, history of depression or angry affects did not distinguish between th two groups. The interviewer's blind rating on the BPRS also revealed similar

differences as well as increased mannerisms and reported guilt in the low accuracy tracking group. The more detailed interview questions also revealed decreased sexual activity and satisfaction and greater perceptual distortions in the low accuracy trackers compared to the high accuracy trackers.

The correlations between SPEM accuracy and individual items or the rating scales generally revealed a similar picture (Table II). Items reflecting impaired social and heterosexual skills were most strongly associated with low accuracy SPEM.

There were no significant differences between the groups with regard to family history of schizophrenia, depression, mania, alcoholism, suicide, mental retardation, criminality, personality disturbances, or unusual, eccentric behavior. The prevalence of separations, divorces, adoptions, marriage between relatives, or inability to complete schooling were also not different between the two groups as reported by the subjects themselves. There was a positive correlation between averaged quantitative ratings and family history of depression ($r=0.39$, $n=36$, $p<0.05$) but no other correlations were significant.

Significantly more low accuracy trackers showed evidence of mild neurologic dysfunction as observed on neurologic examination and in visual and auditory evoked potential latencies. Although the two groups did not differ significantly in the total score on the standardized neurologic exam (confirmed low accuracy trackers 130 ± 150 (n=10), high accuracy trackers 46 ± 47 (n=9) p=NS), averaged tracking accuracy correlated highly with the total score of neurologic "soft signs" across the entire sample (Table 3). EEG abnormalities and slowed late auditory and visual evoked potentials were positively correlated with low accuracy tracking (Table 3), although none of these items significantly discriminated the two groups due to the variance in these measures within groups.

On the continuous performance task, there were no significant differences between the two groups in errors of commission, errors of ommission, and mean interstimulus interval with the low accuracy tracking group showing great variability in their CPT performance. However, significant correlations were observed between tracking accuracy as assessed by the infrared technique using the log signal-to-noise ratio (low=inaccurate tracking) and both errors of commission ($r= -0.52$, $p<0.005$), and mean interstimulus interval ($r= -0.51$, $p<0.005$).

The median reaction time in the seven confirmed low accuracy trackers (300 ± 70 msec) was significantly longer than in the eight high accuracy trackers (23 ± 22 msec) ($p<0.05$) tested in this paradigm. There was a trend for the low accuracy trackers to have a longer reaction time to a stimulus following a long (8 msec) preceding preparatory interval in an irregular interval presentation (confirmed low accuracy trackers 286 ± 73 msec, n=7; high accuracy trackers 230 ± 28 msec; n=8; $p<0.07$) and a greater set index, an index developed by Rodnick and Shakow (1940) to distinguish schizophrenics reaction time from controls (confirmed low accuracy trackers 3854 ± 1253, n=11; high accuracy trackers 3174 ± 445, n=12; $p<0.1$). Accuracy of tracking as evaluated by IR utilizing the log signal-to-noise ratio (low=inaccurate) was negatively correlated with the reaction time to a stimulus following a short (2 msec) preparatory interval in an irregular interval presentation ($r= -0.62$, n=20, $p<0.005$) and to a stimulus following a long (8msec) preceding preparatory interval ($r= -0.60$, n=20, $p<0.005$). The log signal-to-noise ratio was also negatively correlated with the set index ($r= -0.44$, n=30, $p<0.05$).

Platelet MAO activity, plasma amine oxidose activity, and DBH activity were not significantly different between the confirmed low accuracy tracking group and the high accuracy tracking group and did not correlate with eye tracking accuracy across the entire sample.

Discussion:

These results suggest that inaccurate SPEM may be a sensitive marker reflecting neurointegrative dysfunction that, even in the absence of specific neurologic illness, may broadly be associated with significant social, cognitive, and perceptual impairment. These findings are consistent with two other studies demonstrating an association between "psychoticism" and SPEM impairment in normal volunteers (Iacono, 1980; Van der Bosch, 1984). The SPEM impairment is particularly manifest in the social sphere with decreased competence and satisfaction from heterosexual or peer interaction as well as in a tendency to cognitive distortions and perceptual aberrations. The clinical symptomatology formed a specific pattern of disturbances that did not seem to reflect generalized psychopathology, as a variety of impulsive, antisocial, and affective psychopathologic characteristics were either no different between groups or less prevalent in the low accuracy tracking group. Many of the psychopathologic characteristics observed in the impaired tracking group have been associated phenemonologically and genetically with schizophrenia (Kendler, 1982, in press; Gunderson, et al. 1983, in press) and thus have become the basis of a new diagnostic category in DSM-III, Schizotypal Personality Disorder, which was significantly more prevalent in our low accuracy tracking sample than in our high accuracy tracking sample (Siever et al. 1984). SPEM dysfunction is associated with schizophrenia in numerous studies of psychiatric patients (Holzman et al, 1978; Lipton et al, 1983). These findings suggest that, in a functional population that is non-psychiatrically defined population, in which schizophrenia would be expected to be rare, SPEM impairment is associated with clinical characteristics that are similar in character although not as severe as those associated with schizophrenia.

The lack of significant differences in most epidemiologic, demographic, and medical history data suggest that the two groups are broadly similar across a wide variety of these characteristics. These similarities between the two samples lend weight to the specificity of findings of differences between the two groups in the particular clinical characteristics reported.

The most robust associations were observed between the characteristics of heterosexual and social dysfunction or satisfaction, raising the possibility that these areas are most vulnerable to disruption by subtle neurointegrative dysfunction. These characteristics were most commonly observed in the low accuracy tracking group, while cognitive or perceptual disturbances, although clustered in the low accuracy trackers, were less uniformly prevalent in this group. Studies of relatives of schizophrenics also suggest that these characteristics reflecting social incompetence are more likely to characterize affected relatives (Gunderson et al.,1983; Siever et al., in press; Torgerson et al., in press). Psychopathology associated with impulsive characteristics such as drug or alcohol abuse or legal problems, e.g., conviction or imprisonment, usually for moving violations associated with alcohol use, were more prevalent in the high accuracy trackers.

It cannot be determined from this study whether the high accuracy trackers represented a more impulsive subpopulation than the norm in this college sample or whether this difference reflected the marked social isolation and inhibition of the low accuracy trackers, consistent with previous findings of decreased sensation-seeking in low accuracy trackers (Siever et al, 1982). The fact that impulsive characteristics were not correlated with accuracy of tracking in this sample lends weight to the latter interpetation.

Family history of psychiatric and medical illness, for the most part, did not distinguish between the two groups. Although many of the subjects had

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Family history of psychiatric and medical illness, for the most part, did not distinguish between the two groups. Although many of the subjects had schizophrenia-like characteristics, there was no increased prevalence of schizophrenia in the relatives of the low accuracy trackers. As ascertainment was only on the basis of the subject's report and the prevalence of schizophrenia, even in the relatives of schizophrenics themselves, is quite low (Abrams et al,), sample sizes of at least 3-4 times those in this study coupled with more comprehensive family history assessment would be required to detect modest increases in prevalence of schizophrenia in the relatives of the low accuracy trackers. However, the failure to find such an increased prevalence in this population is consistent with other studies which did not find an increased prevalence of schizophrenia in the relatives of patients clinically defined as having schizotypal personality disorder (Torgerson , Soloff , Schultz).The relationships between tracking impairment and family history of depression only emerged from a correlational analysis and diagnostic precision was not sufficient given the source of information to determine whether the depressive symptoms were primary or secondary to personality disorders in the relatives.

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The results of the neurologic examination and EEG suggest that SPEM impairment may reflect broader but subtle neurointegrative dysfunction. The examination scoring emphasized items reflecting dyscoordination of complex movements and failure of inhibition of competing movements rather than discrete, focal neurologic signs. Thus, although the low accuracy trackers would not necessarily be considered specifically neurologically impaired, low accuracy tracking was associated with subtle disintegration of motor behavior. EEG abnormalities, although infrequent, were clustered in the low accuracy trackers and usually consisted of mild, diffuse cortical slowing suggesting inadequate cortical activation. The trends towards delayed latencies of auditory and visual evoked potentials parallel similar finding in schizophrenics

(Roth ; Buchsbaum) and in university students with ind disturbance in cognitive organization (Muller et al ; Calts et

Although low accuracy trackers did not perform significantly w CPT than high accuracy trackers, consistent with our previous study al., 1982), there was a correlation in the whole sample between deg inaccuracy of tracking and both errors of commission and mean inter interval, suggesting that failure to accurately follow the target w with both slower responses and more responses to stimuli sequences appropriate. The correlation appeared to be due to heterogeneity i accuracy trackers' performance, while high accuracy trackers were r uniform in their performance. Thus attentional factors related to performance may sometimes be, but are not necessarily, associated w SPEM.

The decreased reaction time particularly in the irregular tria preceding preparatory intervals suggest another psychophysiologic s between the low accuracy tracking subjects and schizophrenics (Shal Zahn, 19 ; Neuchterlain, 19). These findings also support the h that the low accuracy trackers have an attentional impairment that observed in schizophrenia across a variety of psychophysiologic va

As in a previous study no relationship was found between accu pursuit movements and platelet or plasma amine oxidose activities al., 1982). The relationship between platelet MAO and schizophren to be specific for schizophrenia and more likely reflects a dimens sensationseeking and affectivity (Murphy et al., 19 ; Siever and 19). Abnormally low DBH activity has been reported to be associ attentional disturbance in normals (Buchsbaum et al, 1978), but no associated with schizophrenia ( ). We found n between attentional performance as reflected in SPEM impairment an activity.

as a dopaminergic abnormality which "amplifies" this defect may be required for overt psychosis to be oberved (Siever et al, 1982). The strong association of SPEM impairment with subtle neurologic altentional, and clinical abnormalities similar to those observed in schizophrenics suggest it may provide a promising marker with which to examine such hypotheses.

Table I

Differences between confirmed low accuracy trackers and high accuracy trackers

	Increased in Confirmed Low Accuracy Trackers	Decreased in Confirmed Low Accuracy Trackers
Rating scale for borderl line schizotypal characteristics (Gunderson, et al., 1983)	Eccentricity*	
	Flattened, contricted affect***	
	Referential ideas, especially persecuitory*	
	Altentional, concentration, word-finding disturbance*	
	Socially isolated, detached**	
	Inadequate rapport**	
	Suspicious*	
Brief Psychiatric Rating Scale (BPRS)	Blunted affect***	
	Social incompetence**	
	Guilt*	
	Mannerisms*	
	Total BPRS score***	
Structured interview	Married*	Grade point average*
	Feelings of unreality*	Dates**
	Altered perception of body***	Sexual satisfaction*
	Hold feelings in*	Close friends*
	Guilt*	Performance in sports***

*p<0.05
**p<0.01
***p<0.005

Table II

Correlations Between SPEM Accuracy and Clinical Characteristics

	Correlation with ln/S/N (n = 37)	Correlation With Averaged Qualitative Rating (Cn = 38)
Sexual satisfaction[3]	0.51***	-0.52***
Number of friends[3]	0.50***	-0.39*
Referential ideas[1]	-0.47**	0.24
Social isolation[1]	-0.46***	0.43**
Loss of function[2]	-0.46***	0.32*
Sports performance[3]	0.45***	-0.41*
Brief delusions[1]	-0.43**	0.30
Odd associations[1]	-0.38*	0.27
Social incompetence[2]	-0.37*	0.38*
Conceptual disorganization[2]	-0.37*	0.32*
Sexual deviance[3]	-0.34*	0.34*
History of dating[3]	(+)0.31*	-0.35
Close friends[3]	0.24	-0.43**
Number of dates/month[3]	0.24	-0.45*
Suspiciousness	-0.24	0.35*
Conventional occupational choice[3]	0.23	-0.35*
Realistic occupational goal[3]	0.23	-0.45**
Feelings of unreality[3]	0.23	0.37*

Ta. II

Correlations between accuracy and clinical characteristics

	Correlation with averaged quantitative rating	Correlation with averaged qualitative rating	Correlation with ln S/N
Sexual satisfaction[3]	-0.65***	-0.52***	0.51***
Social incompetence[2]	0.62***	0.38*	-0.37*
Social isolation[1]	0.61***	0.43**	-0.46***
Conceptual disorganization[2]	0.58	0.32*	-0.37*
History of dating[3]	-0.56***	-0.35*	-0.31
Loss of function[2]	0.56***	0.32*	-0.46***
Close friends[3]	-0.55***	-0.43**	0.24
Realistic occupational goal[3]	-0.54***	-0.45**	0.23
Number of friends[3]	-0.52***	-0.39*	0.50***
Sports performance[3]	-0.52***	-0.41*	0.45***
Feelings of unreality[3]	0.50***	0.37*	-0.23
Out of body experiences[3]	0.45**	0.22*	-0.15
Brief delusions[1]	0.44**	0.30	-0.43**
Referential ideas[1]	0.44**	0.24	-0.47*
Number of dates/month[3]	-0.43*	-0.45*	0.24
Auditory illusions[3]	0.43**		

Table II (cont)

	Correlation with averaged quanitative rating	Correlation with averaged qualitative rating	Correlation with ln S/N
Mannerisms[2]	0.42**	0.29	-0.18
Suspiciousness[1]	0.42*	0.35*	-0.24
Odd experiences[3]	0.42*	0.30	-0.20
Emotional withdrawl[2]	0.39*	0.20	-0.17
Sexual deviance[3]	0.39*	0.34*	-0.34*
Conventional occupational choice[3]	-0.38*	-0.35*	0.23
Eccentricity[1]	0.38*	-0.15	-0.10
Flattened affect[1]	0.38*	0.30	-0.19
Odd associations[1]	0.38	0.27	-0.38*
Inadequate rapport[1]	0.38*	0.27	-0.20

*p<0.05
**p<0.01
***p<0.001

Table III

Correlations between accuracy of SPEM and neurologic variables

	Averaged qualitative rating	Log signal-to-noise ratio
Neurologic exam score (n=25)	0.42*	-0.62***
Electroencephalographic abnormality (n=24)	0.35	-0.51*
Visual evoked potential latency (n=27)		
(os)left eye	0.29	-0.52**
(ou)both eyes	0.37	-0.60***
Auditory evoked potential latency (n=24)		
right eye		
AD3 (third peak)	0.30	-0.19
AD5 (fifth peak)	-0.40	0.57***
left eye		
AS3	0.37	-0.30
AS5	0.47*	-0.27*

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