A reevaluation of sustained attention performance in temporal lobe epilepsy

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Abstract

Reports of normal Continuous Performance Test (CPT) accuracy in patients with temporal lobe epilepsy (TLE) stand in contrast to a demonstration of nonspecific absolute reaction time (RT) deficits in this population. In this study, we examined CPT data from a TLE sample for potential RT deficits across three consecutive blocks of time during the vigil. Seventeen patients with medically intractable epilepsy of temporal lobe origin and 17 healthy volunteers participated. The Conners CPT was used to assess sustained attention over a 14-min vigil. There were no significant group differences in accuracy. There was, however, a significant interaction between groups and time intervals, with disproportionate RT increases for patients at the end of the vigil. These findings are consistent with a report of nonspecific RT deficits in TLE despite normal accuracy scores, and further indicate impaired RT performance over time.

Keywords: Temporal lobe epilepsy; Continuous performance test; Sustained attention; Vigilance; Reaction time; Assessment

1. Introduction

Consistent with previous reports of normal Continuous Performance Test (CPT) accuracy in patients with temporal lobe epilepsy (TLE; Lansdell & Mirsky, 1964; Mirsky, Primac,
Marsan, Rosvold, & Stevens, 1960), we recently reported that discrimination accuracy in TLE patients is comparable to that of healthy volunteers (Mean = 3.5, S.D. = 0.9, and Mean = 3.3, S.D. = 0.9, respectively; Fleck et al., 1999). In contrast to reports of normal CPT response accuracy, one study has demonstrated nonspecific absolute reaction time (RT) deficits in TLE patients (Goldstein, Rosenbaum, & Taylor, 1997). This finding is consistent with evidence from our lab indicating that overall RT measures may be more sensitive to sustained attention deficits in patients with bipolar disorder than are accuracy measures (Wilder-Willis et al., 2001). Moreover, we have demonstrated dissociations between the patterns of inattention exhibited by patients with bipolar disorder or schizophrenia when RT performance is examined over the course of a CPT vigil (Fleck, Sax, & Strakowski, in press).

With the above considerations in mind, we reexamined the CPT data from our TLE sample to evaluate potential attention deficits across early, middle, and late stages of the vigilance period. We reasoned that if RT is more sensitive than accuracy to sustained attention deficits in focal epilepsy, then patients would be impaired on hit RT and/or hit RT variability, particularly late in the vigil, but that hit rates would be spared.

2. Methods

2.1. Participants

Seventeen patients (7 men and 10 women) with medically intractable complex-partial seizures were recruited from the inpatient Epilepsy Monitoring Unit at the University of Cincinnati Medical Center. The site of the epileptogenic focus was determined by the consensus of a multidisciplinary treatment team, which included a neurosurgeon and a neurologist who determined localization on the basis of continuous video telemetry–EEG monitoring with scalp electrodes and magnetic resonance imaging (MRI). The tests included in the present study were not used in seizure localization.

All patients were candidates for temporal lobe resection and suffered from unilateral TLE originating in the left (n = 7) or right (n = 10) cerebral hemisphere. Nine patients (53%) had evidence of temporal lobe pathology on MRI (patients with obvious extratemporal lobe pathology were excluded). The mean age at seizure onset was 17 years (range of 1–40 years), and the mean duration of the seizure disorder was 18 years (range of 3–40 years). All patients were 50 years old or younger (range of 15–50 years); had at least 8 years of education (most had completed high school; range of 8–16 years); functioned at or above the borderline range of overall intellectual ability (i.e., Full Scale IQ > 70; range of 72–108); and were free from other neurological conditions and serious psychiatric disorders, including major depressive disorder, as determined by clinical interview and medical records. The patients did not differ significantly on any of the above-mentioned demographic characteristics as a function of hemispheric focus (Mann–Whitney U, P’s > 0.05). For the purpose of EEG monitoring and prior to testing, each patient was either tapered off antiepileptic medications completely or to a reduced dose. They were tested 48 h after the last medication adjustment, and no patient had experienced a seizure within the 24 h prior to testing. One patient was identified as an outlier.
on the attentional measures (i.e., performance two S.D.’s lower than the group mean) and excluded from further analysis.

Seventeen healthy volunteers (11 men and 6 women) were recruited from the undergraduate population at the University of Cincinnati. Healthy volunteers were free from gross cognitive deficits, neurological conditions, and serious psychiatric disorders, as determined by a clinical interview performed by a neuropsychologist. One healthy volunteer, the nearest demographic match to the excluded patient, was dropped from the subsequent analysis. Memory data for the patient and control samples have been reported previously (Fleck et al., 1999).

2.2. Continuous performance task

The CPT (Connors, 1992) assessed sustained attention over a 14-min vigilance period, during which time letters appeared on a computer screen for 250 ms, one letter at a time. Participants were required to depress the space bar as quickly and accurately as possible for any letter of the alphabet except the letter “X,” which appeared on 10% of the 360 total trials. Performance was separated into three consecutive blocks of 120 trials each, and six subblocks of 20 trials each with interstimulus intervals (ISIs) of 1, 2, or 4 s.

According to Connors (1992), long ISIs can be detrimental to RT performance, because arousal tends to decrease as stimuli are presented more slowly. Further, an inability to maintain consistent performance speed as ISIs change is indicative of fatigue. The measures of primary interest are thought to be more consistent with attention than fatigue and included hit rate, hit RT, and hit RT variability across the three consecutive blocks.

Table 1

<table>
<thead>
<tr>
<th>Demographic or clinical variable</th>
<th>Healthy (n = 16)</th>
<th>Patient (n = 16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean years (S.D.)</td>
<td>23.6 (2.1)</td>
<td>34.5 (9.0)</td>
</tr>
<tr>
<td>Education, mean years (S.D.)</td>
<td>13.2 (1.5)</td>
<td>12.4 (2.3)</td>
</tr>
<tr>
<td>Sex, women n (%)</td>
<td>6 (38)</td>
<td>10 (63)</td>
</tr>
<tr>
<td>Race, Caucasian n (%)</td>
<td>14 (88)</td>
<td>14 (88)</td>
</tr>
<tr>
<td>WAIS-R, mean Full Scale IQ (S.D.)</td>
<td>105.5 (5.6)</td>
<td>86.9 (10.1)</td>
</tr>
<tr>
<td>CRT, mean milliseconds (S.D.)</td>
<td>618.3 (80.4)</td>
<td>824.0 (155.9)</td>
</tr>
<tr>
<td>Impaired hit rate, n (%)</td>
<td>6 (38)</td>
<td>6 (38)</td>
</tr>
<tr>
<td>Impaired hit RT variability, n (%)</td>
<td>1 (6)</td>
<td>10 (63)</td>
</tr>
<tr>
<td>Impaired hit RT, n (%)</td>
<td>3 (19)</td>
<td>9 (56)</td>
</tr>
<tr>
<td>Impaired hit RT ISI change, n (%)</td>
<td>6 (38)</td>
<td>9 (56)</td>
</tr>
</tbody>
</table>

WAIS-R = Wechsler Adult Intelligence Scale-Revised; CRT = Choice Reaction Time Test.

a \( t(30) = 6.10, P < .001 \)

b \( t(30) = 6.31, P < .001 \)

c \( t(30) = 4.59, P < .001 \)

d \( \chi^2 = 11.22, P < .001 \)

e \( \chi^2 = 4.44, P < .05 \)
Fig. 1. Mean hit rate (%), hit RT variability (milliseconds), and hit RT (milliseconds) adjusted for age, Full Scale IQ, and CRT in the patient and healthy volunteer groups across early, middle, and late stages of the vigilance period.
3. Results

As shown in Table 1, healthy volunteers were significantly younger, had higher Full Scale IQ scores, and were faster at response execution than patients. However, there were no within-group correlations between these clinical characteristics and the performance measures. To be statistically conservative, age, IQ, and Choice Reaction Time (CRT; to control psychomotor slowing due to medications) were included as covariates in the analyses of variance (ANOVA). \(\chi^2\) Analyses revealed that a greater proportion of patients than healthy volunteers were clinically impaired relative to normative data on hit RT and standard error of hit RTs, but not on hit rate or hit RT ISI change (see Table 1).

As illustrated in Fig. 1, hit rates occurred at near ceiling levels for both patients and healthy volunteers, and there were no significant Group, Block, or interaction effects. For hit RT variability, the main effect of Group \(F(1,27) = 3.88, P < .06\) and the Block \(\times\) Group interaction approached significance \(F(2,54) = 3.04, P < .06\). Hit RT produced the only significant main effect of Group \(F(1,27) = 5.23, P < .05\), qualified by a significant Block \(\times\) Group interaction \(F(2,54) = 3.30, P < .05\). Post hoc comparisons within the patient group revealed significant differences between Blocks 2 and 3 \(t(15) = 2.43, P < .05\) and Blocks 1 and 3 \(t(15) = 2.14, P < .05\), indicating that the patient group’s increased latencies at the end of the vigil accounted for the interaction. There were no significant RT differences between blocks in the control group.

4. Discussion

In this study, we examined the sustained attention capabilities of TLE patients with age, IQ, and overall psychomotor processing speed statistically controlled. According to normative CPT performance data, six patients and six healthy volunteers had atypically low hit rates, suggesting that this measure had low sensitivity in discriminating patients from controls. When the data were examined as group means, the patients and healthy volunteers both performed well across time on hit rate. However, near-ceiling levels of performance restricted the range of possible scores, making it difficult to identify the performance decrements expected on tests of sustained attention.

In contrast to the similar hit rate performance between groups, a greater percentage of patients than controls fell into the clinically impaired range on hit RT and hit RT variability according to normative CPT data. Additionally, a significant Block \(\times\) Group interaction was identified for hit RT. Although both groups improved slightly on RT from Blocks 1 to 2, the healthy volunteers continued this pattern through Block 3, a learning effect, while the patients showed a large performance decrement between Blocks 2 and 3, a sustained attention deficit. Thus, RT was the only performance measure sensitive to attention deficits over time. The hit RT variability analysis indicated trends toward more variable RTs over time on the part of patients and less variable responses on the part of healthy volunteers, although this finding did not reach statistical significance. Note that the groups were similarly variable at the beginning of the vigil, reflecting the expected CPT finding of comparable baseline perform-
The mean RT deficits were not likely due to fatigue, because the percentage of patients in each group who were impaired on hit RT ISI change was not statistically different. These findings are consistent with a report of nonspecific RT deficits in TLE despite normal percent correct scores (Goldstein et al., 1997), and extend these findings by demonstrating a RT increment that has clinical implications. Together with previous work, these data suggest that it is important to examine performance decrements over time, which may be greater for patients than healthy volunteers (i.e., a Block × Group interaction; Corkum & Siegel, 1993; Neuchterlein, 1991). Additionally, RT measures may provide critical information when the vigilance period is relatively short, as accuracy performance (e.g., perceptual sensitivity and hit rate) may either occur near ceiling levels (Fleck et al., 1999) or be otherwise insensitive to differences across time (Fleck et al., in press). For example, in the present study, RT increased sharply at the end of the vigil for patients while accuracy remained unchanged. The ceiling-level hit rates precluded the strategy of trading speed for accuracy at the end of the vigil and indicate that the RT increment in patients is consistent with a processing deficit. Studies employing lower target probabilities than reported here (i.e., 90%) tend to decrease accuracy ceiling effects, thereby increasing error variability and sensitivity (Pachella, 1974), but error rates have been insensitive to TLE under these circumstances nonetheless (Lansdell & Mirsky, 1964; Mirsky et al., 1960).

The implications of this study must be considered in light of several sample limitations. First, the sample size was relatively small. Although a power analysis indicated that the sample size was sufficient for repeated-measures analyses, the results may have somewhat limited generalizability. Second, the patient and healthy volunteer groups were poorly matched on age, IQ, and psychomotor processing speed. In this respect, however, it is noteworthy that there was no significant correlation between these characteristics and the performance measures. Third, although RT measures appear to be sensitive to attentional disturbance in patients with TLE, the lack of a patient control group (e.g., generalized or extratemporal seizures) precludes conclusions regarding the specificity of the RT loss over time. It is also possible that patients with less severe illness than those in our sample may not show any RT deficit.

It should also be noted that some patients were receiving subtherapeutic doses of antiepileptic medications at the time of testing. Although doses below the therapeutic range are less likely to cause central nervous system depression and, in turn, slower overall RT, this effect cannot be completely ruled out by controlling total CRT. However, medications generally have a deleterious influence on overall mean RT, and not on the differential patterns of RT performance between groups. In order to examine further the influence of medications on hit RT slowing, we conducted a simple count of the number of participants who performed either more slowly or more rapidly between the middle and end of the vigil to any degree. The count revealed that a majority of patients performed more slowly at the end of the vigil (87.5%), while a majority of healthy volunteers performed more rapidly (68.75%; \( \chi^2 = 10.49, P < .01 \)). Considering the comparable hit RT decreases from the early to middle stages of the vigil, it seems unlikely that medications would slow each patient’s performance in such a specific manner late in the vigil.
Although general CPT RT deficits appear to be sensitive to both neuropathology (Goldstein et al., 1997) and psychopathology (Fleck et al., in press), to our knowledge, this is the first study to document a specific pattern of RT change across a vigilance period in TLE. The findings are consistent with the possibility that a late-acting impairment of subcortical arousal or faulty frontal–subcortical integration is involved in TLE (e.g., Calloway & Naghdi, 1982). Large-scale, multiple-group studies that include other patient populations may help to further characterize the capability of patients with epilepsy to sustain attention.

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References


