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A COMPONENTIAL ANALYSIS OF PROVERB INTERPRETATION IN PATIENTS WITH FRONTAL LOBE EPILEPSY AND TEMPORAL LOBE EPILEPSY: RELATIONSHIPS WITH DISEASE-RELATED FACTORS

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Abstract

The ability to interpret nonliteral, metaphoric language was explored in patients with frontal lobe epilepsy (FLE) and temporal lobe epilepsy (TLE), and matched control participants, to determine (1) if patients with FLE were impaired in their interpretations relative to those with TLE and controls, and (2) if disease-related variables (e.g., age of seizure onset) predicted performances in either patient group. A total of 22 patients with FLE, 20 patients with TLE, and 23 controls were administered a test of proverb interpretation to assess their ability to grasp the abstract meaning of nonliteral language. Participants were presented with a series of proverbs and asked to provide an oral interpretation of each. Responses to each proverb were scored according to their accuracy and level of abstractness. Patients with FLE, but not TLE, were impaired relative to controls in their overall interpretation of proverbs. However, a subgroup analysis revealed that only patients with left FLE showed impaired interpretation accuracy relative to the other groups, whereas patients with both left FLE and left TLE showed impaired abstraction. Patients with FLE were also impaired when they were asked to select the best interpretation of the proverb from response alternatives. In patients with FLE, only a left-sided seizure focus was associated with poorer performance. In patients with TLE, both an early age of onset and a left-sided seizure focus predicted poorer performance. Overall, FLE patients exhibit greater impairment than TLE patients in interpreting proverbs. However, the nature and disease-specific correlates of impaired performances in proverb interpretation differ between the groups.

Keywords

Cognition; Executive functions; Metaphoric language; Nonliteral language; Seizure disorder; Verbal abstract reasoning

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INTRODUCTION

The ability to interpret nonliteral or metaphoric language is a higher-level aspect of verbal functioning that is often impaired in patients with frontal lobe dysfunction (Berg, Bjornram, Hartelius, Laakso, & Johnels, 2003; Pearce, McDonald, & Coltheart, 1998; Sponheim, Surerus-Johnson, Leskela, & Dieperink, 2003). Although this skill is frequently assessed in mental status exams and measures of verbal intelligence (Wechsler, 1997), it is seldom evaluated independently of other verbal skills. One method of assessing the ability to interpret nonliteral language is to evaluate the understanding of proverbs, since proverbs are generally brief, concrete phrases that convey a deeper, abstract meaning (Delis, Kaplan, & Kramer, 2001; Gorham, 1956). Successful proverb interpretation requires both fundamental language skills, in that one must understand the meaning of the words and be able to express one's responses, as well as higher-level executive functions, in that one must integrate the meanings of the words into a coherent, abstract principle or concept (Delis et al., 2001). Proverb interpretation has been shown to correlate with other executive functions, including planning, problem solving, fluency, and set shifting in patients with frontal lobe dysfunction (Brune & Bodenstein, 2005; Sponheim et al., 2003), suggesting that impaired proverb interpretation may reflect a more generalized deficit in executive functioning.

Despite its clinical value and implications for patients with frontal lobe dysfunction, the ability to interpret proverbs has not been investigated in published studies of patients with frontal lobe epilepsy (FLE) or temporal lobe epilepsy (TLE). The lack of literature on this topic is surprising, since impairments in abstract reasoning are commonly reported in patients with FLE (Devinsky et al., 1997; Fowler, Richards, Berent, & Boll, 1987; Giovagnoli, 2001; Upton & Thompson, 1996), and occasionally in patients with TLE, who have been found to show more subtle signs of frontal lobe dysfunction (Fowler et al., 1987; Giovagnoli, 2001; Hermann & Seidenberg, 1995; Hermann, Wyler, & Richey, 1988). For example, Upton and Thompson (1996) reported that patients with FLE were impaired relative to controls on two tests involving abstract reasoning; a Twenty Questions Test (Klouda & Cooper, 1990) and a modified Wisconsin Card Sorting Test (WCST) (Nelson, 1976). However, patients with TLE were not included in the study and thus relative impairments in FLE versus TLE could not be determined. Findings from studies including patients with both FLE and TLE have been mixed. Some studies have reported greater impairments in abstract reasoning in patients with FLE (Milner, 1964), while others have reported equivalent levels of impairments in FLE and TLE (Exner et al., 2002; Giovagnoli, 2001). However, the extant literature on abstract reasoning in patients with epilepsy has primarily used nonverbal measures (i.e., WCST, Raven's Progressive Matrices) that tap a variety of higher-level skills (i.e., set shifting, problem solving, working memory) in addition to abstract reasoning. Evaluating proverb interpretation in patients with FLE and TLE may unveil unique impairments in *verbal* abstract reasoning in one or both patient groups that are not currently appreciated in the literature.

There are also a number of seizure-related variables that have been found to influence the nature and degree of cognitive impairment in patients with epilepsy and could affect their ability to interpret nonliteral language. These variables include the age of seizure onset (Dikmen, Matthews, & Harley, 1975, 1977; Hermann et al., 2002; Lespinet, Bresson,

N'Kaoua, Rougier, & Claverie, 2002; O'Leary, Seidenberg, Berent, & Boll, 1981), duration of illness (Jokeit & Ebner, 1999; Oyegbile et al., 2004), seizure frequency (McDonald, Delis, Norman, Wetter, Tecoma, & Iragui, 2005c; Thompson & Duncan, 2005), number of anticonvulsant medications (G. K. Motamedi & Meador, 2004), and the presence or type of structural pathology (McDonald, Delis, Norman, Tecoma, & Iragui, 2005a; York et al., 2003). For example, patients with TLE who have an early age of seizure onset have been found to show more pervasive cognitive impairments in general than those with a late seizure onset (Hermann et al., 2002; Lespinet et al., 2002), even after controlling for the duration of illness and seizure frequency (Dikmen et al., 1977). In addition, patients with a left-sided seizure focus have been shown to perform more poorly on a variety of verbal tasks relative to those with right-sided seizure focus (Akanuma et al., 2003; Bell & Davies, 1998; Giovagnoli, 1999, 2005; Upton & Thompson, 1996). However, the vast majority of studies examining the influence of these seizure-related variables on cognition included only patients with TLE (Hermann et al., 2002; Jokeit & Ebner, 1999; Lespinet et al., 2002; Oyegbile et al., 2004) or did not differentiate between patients with temporal and nontemporal seizure foci (Dikmen & Matthews, 1977; Thompson & Duncan, 2005). In addition, few studies have focused on the effects of disease-related factors in patients with epilepsy on different aspects of executive functioning, such as proverb interpretation (but see Thompson & Duncan, 2005).

In the present study, we evaluate patients with FLE, TLE, and healthy controls on a proverbs test in order to determine whether or not patients with FLE show impaired interpretation of nonliteral language relative to TLE patients and controls. In addition, we examine whether or not important disease-related variables, including the side of the seizure focus, seizure frequency, age of seizure onset, illness duration, lesion status, and/or number of anticonvulsant medications predict the accuracy and/or abstractness of proverb interpretations in either patient group. Based on the existing literature in patients with frontal-lobe dysfunction, we hypothesized that (1) relative to patients with TLE and healthy controls, patients with FLE would be impaired when generating proverb interpretation as a result of poorer abstraction and accuracy of their responses relative to the other two groups; (2) patients with FLE would select more of the concrete responses relative to the other groups when provided with response alternatives, indicating difficulty with recognizing and appreciating abstract thought; and (3) impaired performances in patients with FLE and TLE would be associated with an early age of seizure onset, a longer illness duration, and an increased number of seizures. In addition, we predicted that patients with a left-sided seizure focus would perform more poorly than those with right-sided seizure focus due to the high language demands of the task.

METHOD

Participants

Participants in this investigation were 22 patients with FLE, 20 patients with TLE, and 23 healthy controls. All patients were recruited from the University of California, San Diego, Epilepsy Center and diagnosed by a board-certified neurologist with expertise in epileptology. The study was approved by the Institutional Review Board (IRB) and was

performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. All participants provided written consent prior to enrollment in the study. Patients were classified according to ictal and interictal video-EEG telemetry, seizure semiology, and neuroimaging. Participants with either an epileptic focus or radiological evidence of dysfunction outside the frontal or temporal regions were excluded. The sample of FLE participants consisted of 11 patients with unilateral right FLE, 10 with unilateral left FLE, and 1 patient with bilateral FLE. Of the FLE group, 15 patients showed structural lesions on neuroimaging (7 right, 7 left, 1 bilateral), whereas the remaining 7 FLE patients exhibited no identifiable structural lesion (4 right, 3 left). Risk factors within the FLE groups included no known risk factors ($N = 9$), encephalitis ($N = 1$), arteriovenous malformation ($N = 1$), cavernous angioma ($N = 2$), tumor ($N = 4$; oligoastro-meningioma, cytoma, lipoma, low-grade glioma), and head injury with focal frontal encephalomalacia ($N = 5$). Two of the patients with FLE were left-handed. The FLE group consisted of 13 females and 9 males.

In all 20 patients with TLE, the diagnosis was based on the presence of ictal and interictal temporal-lobe epileptiform activity as monitored by video-EEG telemetry. Diagnoses were supported in all patients by the presence of mesial temporal lobe atrophy consistent with mesial temporal sclerosis (MTS) and no evidence of dual pathology on MRI. The sample of TLE patients consisted of 8 patients with unilateral right TLE, 11 with unilateral left TLE, and one patient with bilateral TLE. Risk factors for epilepsy within the TLE group included no known risk factors ($N = 14$), meningitis ($N = 2$), encephalitis ($N = 1$), and head injury ($N = 3$). Three of the patients with TLE were left-handed. The TLE group consisted of 13 females and 7 males.

All patients in the FLE and TLE groups were taking one to three anticonvulsant medications at the time of the evaluation. Medications included valproic acid, phenytoin, felbamate, carbamazepine, clonazepam, levetiracetam, lamotrigine, primidone, topiramate, oxcarbazepine, and zonisamide.

A total of 23 healthy participants were randomly selected from the Delis-Kaplan Executive Function System (D-KEFS; Delis et al., 2001) national database to serve as a control group after filtering for similar age, education, and gender to the patient groups. The control group consisted of 13 females and 10 males. Table 1 displays demographic characteristics and selected neuropsychological performances for the control and patient groups. In addition, estimated Verbal IQ (Wechsler Test of Adult Reading; WTAR) (Wechsler, 2001), self-reported depression score (Beck Depression Inventory-Second Edition; Beck-II) (Beck, 1996), and epilepsy features were available for the FLE and TLE patient groups. One-way analysis of variances (ANOVAs) revealed no significant differences among the three groups in age, $F(2, 64) = 0.03$; $p > .05$, or level of education, $F(2, 64) = 0.11$; $p > .05$. A 3 × 2 chi square did not reveal any differences among the three groups in gender distribution ($\chi^2 = 1.5$, $p > .05$). Group differences did emerge in both Letter fluency, $F(2, 64) = 7.5$; $p < .01$, and Category fluency, $F(2, 64) = 5.2$; $p < .01$. On both measures of fluency, the FLE and TLE patients were impaired relative to controls (p-values <.05), but the two patient groups did not differ from one another (p-values >.05). Independent t-tests were also conducted between the FLE and TLE groups and revealed no significant differences in estimated Verbal IQ, $t(40) = 0.60$; $p > .05$, or self-reported depression $t(40) = 0.43$; $p > .05$. Due to the

non-normal distribution of the seizure-related variables, nonparametric tests were used to evaluate group differences. Mann-Whitney *U* tests revealed no significant group differences in age of seizure onset ($U = 0.46$, $p > .05$), illness duration ($U = 0.02$, $p > .05$), self-reported seizure frequency ($U = 0.95$, $p > .05$), or number of anticonvulsant medications ($U = 1.74$, $p > .05$). Chi square tests revealed no significant group differences in the number of FLE and TLE patients taking anticonvulsant medications that have an increased risk of cognitive side effects (Ortinski & Meador, 2004), including primidone ($\chi^2 = 0.29$, $p > .05$), topiramate ($\chi^2 = 0.76$, $p > .05$), phenytoin ($\chi^2 = 0.64$, $p > .05$), valproate ($\chi^2 = 0.05$, $p > .05$), and clonazepam ($\chi^2 = 0.34$, $p > .05$).

Materials and Procedure

The Proverbs Test from the Delis-Kaplan Executive Functions System (D-KEFS) (Delis et al., 2001) was used to measure metaphoric language processing in patients and controls. The Proverbs Test consists of eight sayings from the English language that are presented in two conditions: (1) Free Inquiry and (2) Multiple Choice. In the Free Inquiry condition, the examiner reads each proverb aloud and the participant is asked to provide an oral interpretation of the proverb without assistance or cues. Participants' responses to each proverb are scored in terms of (a) the accuracy of the interpretation, independent of the abstraction level; and (b) and level of abstraction of the interpretation, independent of accuracy (details of the scoring system can be found in the test manual (Delis et al., 2001)). An overall achievement score represents a combination of both the accuracy and abstraction of the response. In the Multiple Choice condition, the same eight proverbs are presented along with four alternative meanings of the proverb and participants are asked to select the best one. For each multiple-choice response set, the four alternatives consist of (a) a correct, abstract interpretation; (b) a correct but concrete interpretation; (c) an incorrect, phonemically similar response; and (d) an unrelated saying (see Table 2).

RESULTS

Table 3 displays the age and education-adjusted performances for the FLE, TLE, and control groups on the Proverbs Test. Analysis of variance (ANOVA) was performed using age- and education-adjusted scores to examine whether or not patients with FLE were impaired relative to patients with TLE and healthy controls in the Free Inquiry condition and whether or not group differences emerged in the accuracy and/or abstractness of responses. Kruskal-Wallis and Mann Whitney *U* tests were used to examine group differences in the Multiple Choice condition due to the non-normal distribution of the scores. An alpha of 0.05 was adopted for all analyses.

One-way ANOVAs revealed significant group differences in the Free Inquiry condition, $F(2, 62) = 4.31$, $p < .05$. Multiple comparisons using Tukey's HSD tests revealed that the FLE group performed more poorly than the control group ($p = .02$), but not significantly different from the TLE group ($p = .70$). Patients with TLE did not differ from controls in the Free Inquiry condition ($p = .15$). Group differences in the accuracy and abstractness of responses were also examined. Although there was not a *significant* group difference in response accuracy, $F(2, 62) = 2.85$, $p = .06$, the FLE group's tendency to provide less accurate

responses than controls approached significance ($p = .052$). Group differences did emerge in the abstractness of responses, $F(2, 62) = 4.72$, $p < .05$. Post-hoc comparisons revealed that both the FLE ($p = .02$) and TLE ($p = .04$) patients provided fewer abstract responses than did controls. Patients with FLE and TLE did not differ from one another in the abstractness of their responses ($p > .05$). Group differences did not reach statistical significance in the Multiple Choice condition when the total score was examined (Kruskal-Wallis $\chi^2 = 3.69$, $df = 2$, $p > .05$). However, analysis of the *types* of response alternatives selected (i.e., *abstract*, *concrete*, *phonemic*, or *unrelated*) revealed significant group differences in abstract ($\chi^2 = 4.84$, $df = 2$, $p < .05$) and concrete ($\chi^2 = 8.14$, $df = 2$, $p < .05$) response selections. FLE patients selected fewer abstract responses ($U = 2.13$, $p < .05$) and more concrete responses ($U = 2.76$, $p < .01$) relative to controls. There were no group differences between FLE and controls in terms of selecting phonemic or unrelated responses (p-values > .05). TLE patients did not differ from FLE patients or controls in the nature of their multiple choice response selections (p-values > .05).

Contribution of Disease-Related Variables

Based on previous findings of factors known to affect cognitive functioning in epilepsy (see G. Motamedi & Meador, 2003, for a review), we examined the degree to which the side of the seizure focus, age of seizure onset, illness duration, number of anticonvulsant medications, and seizure frequency predicted scores in response accuracy and abstractness. In addition, the degree to which the presence or absence of a cerebral lesion affected proverb performance was examined in the FLE group.

Table 4 displays one-way ANOVAs, independent t-tests, and Spearman correlations between seizure-related variables and Proverbs Test performances in the FLE and TLE groups. ANOVAs with subsequent multiple comparisons were performed to examine possible group differences between FLE and TLE patients with left versus right-sided seizure onset. As can be seen, patients with left FLE showed poorer accuracy relative to the other three patient groups, $F(3, 37) = 4.04$, $p < .01$, whereas both the left FLE and left TLE groups showed significantly poorer abstraction than their right-sided counterparts, $F(3, 37) = 3.91$, $p < .05$. Correlational analysis revealed that the age of seizure onset correlated with performances in the TLE patients but not in the FLE patients. No other relationships emerged among the disease-specific variables and proverb scores in the FLE or TLE groups.

To further explore the unique contribution of disease-specific variables to group performances, multiple regression analyses were performed within each group. Because of the high intercorrelation between age of seizure onset and illness duration in the FLE ($r = -.637$, $p < .05$) and TLE ($r = -.821$, $p < .001$) groups, only the variable with the highest correlation to performances (i.e., age of seizure onset) was retained in the regression model. Multicollinearity among the other predictors was low and nonsignificant (tolerance values = .88 to .95).

Within the FLE group, there was a trend for the linear combination of seizure-related variables to predict response accuracy, $F(4, 19) = 1.91$, $p < .10$, accounting for 34% of the variance in scores. However, the side of the seizure focus was the only variable that contributed uniquely to response accuracy: regression coefficient (β) = −.519, $p < .05$.

Having a left-sided seizure focus predicted poorer accuracy in FLE patients when controlling for the other disease-specific variables. The combination of variables did not predict abstraction score or overall group performances in the Free Inquiry condition.

Within the TLE group, the linear combination of variables accounted for 59% of the variance in Free Inquiry scores, $F(4, 17) = 4.61$, $p < .05$. Of the predictors, the side of the seizure focus ($\beta = -.633$, $p <= .01$) and the age of seizure onset ($\beta = .516$, $p < .05$) contributed unique variance. A left-sided seizure focus and an early age of onset predicted poorer scores. With respect to accuracy, the overall regression equation approached significance, $F(4, 17) = 2.58$, p .068, accounting for 43% of the variability in accuracy scores. An early age of seizure onset ($\beta = .533$; $p < .05$) was associated with poorer accuracy in the TLE group. For the abstractness of responses, the combination of variables accounted for a significant amount of the variance in scores (54%) $F(4, 17) = 3.75$, $p < .05$, with both a left-sided seizure focus ($\beta = -.630$; $p < .05$) and an early age of seizure onset ($\beta = .424$; $p < .05$) independently contributing to poorer abstraction in the TLE group.

Diagnostic Accuracy of Proverb Interpretation

In order to further examine the clinical utility of the Proverbs test we compared scores at the individual participant level. Individual participant analyses were performed by calculating the diagnostic accuracy, sensitivity, and specificity in the Free Inquiry and Multiple Choice conditions. Impaired performances were defined as a T-score falling at least 1.5 standard deviations below the mean of the control group (T-score <35). Diagnostic accuracy was based on the true hit rate—i.e., true classification of each group (true positives) added together and divided by the total sample size. Using 1.5 *SD* below the control mean as a cut-off for impairment, 69% of the participants were correctly classified by their Free Inquiry score. The sensitivity (true positives divided by true positives plus false negatives) was only 59%, whereas the specificity (true negatives divided by the combined true negatives plus false positives) was 80%. The high specificity relative to sensitivity reflects the low number of false positives in the TLE group (4 out of 20 left TLE patients were classified as impaired) compared to the relatively high number of false negatives in the FLE patient group (9 out of 22 were classified as not impaired). In the Multiple Choice condition, diagnostic accuracy was 72%, sensitivity was 55%, and specificity was 75% for the entire group. Due to the importance of the side of the seizure focus in the FLE group, we also performed our individual participant analyses with only the left FLE patients included. Inclusion of only left FLE patients increased diagnostic accuracy to 85% and sensitivity to 80%, whereas specificity remained at 80%. Including only left FLE patients in the Multiple Choice condition did not significantly change the results (i.e., diagnostic accuracy = 76%, sensitivity = 60%, and specificity = 75%).

Correlations with Other Executive Function Measures

Because there is evidence that proverb interpretation is related to other executive functions in patients with frontal lobe dysfunction (Brune & Bodenstein, 2005; Sponheim et al., 2003), we examined the intercorrelations between overall proverb interpretation raw scores and scores on tests that assess other domains of executive functioning (i.e., cognitive flexibility, verbal fluency, response inhibition, and planning). Table 5 displays the bivariate correlations

for the FLE and TLE groups between proverb Free Inquiry raw scores and raw scores from the Trail Making Test (Number–Letter Sequencing condition), Verbal Fluency Test (Letter and Category Fluency conditions), Color–Word Interference Test (Inhibition condition), and Tower Test (Total Achievement score) subtests of the D-KEFS. As can be seen, proverb interpretation was highly correlated with other measures of executive functioning in the FLE patients, whereas no significant relationships emerged in the TLE group.

DISCUSSION

This study assessed proverb interpretation in patients with FLE, TLE, and controls in order to determine (1) whether or not patients with FLE were less accurate and/or abstract in their interpretations of proverbs relative to the other groups, and (2) whether or not disease-specific variables predicted performances in one or both patient groups. Based on previous studies of greater executive dysfunction in patients with FLE compared to patients with TLE, we hypothesized that patients with FLE would perform more poorly than those with TLE and healthy controls in their proverb interpretations, and that their impairment would be related to poorer abstraction and accuracy. It was hypothesized that disease-specific variables would predict verbal abstraction in patients with FLE and TLE. Given the verbal nature of the task, we predicted that a left-sided seizure focus would be associated with poorer performances.

In support of our primary hypothesis, results revealed that patients with FLE were impaired relative to controls in their overall interpretation of proverbs. Although the FLE group did not differ significantly from the TLE group at the group level, inspection of individual participant data revealed that proverb scores correctly classified FLE and TLE patients 69% of the time, with 80% specificity to FLE. These data are consistent with recent lesion studies suggesting that the frontal lobes are critical for verbal abstract reasoning skills (Alexander, Benson, & Stuss, 1989; Keil, Baldo, Kaplan, Kramer, & Delis, 2005; Novoa & Ardila, 1987; Pearce et al., 1998), which would be necessary for interpreting nonliteral language. However, our prediction that the FLE group would be more impaired in verbal abstraction than the TLE group was not supported by the group data. Instead, both patient groups provided responses that were less abstract than those provided by controls. This finding is consistent with functional imaging and repetitive transcranial magnetic stimulation research that has implicated both prefrontal (BA 45/47) and temporal lobe (BA 20, 37) regions in the processing of nonliteral compared to literal speech (Oliveri, Romero, & Papagno, 2004; Rapp, Leube, Erb, Grodd, & Kircher, 2004). This finding is also consistent with patient research reporting impaired comprehension of metaphoric speech in patients with damage to prefrontal (de Bonis, Epelbaum, Deffez, & Feline, 1997; Pearce et al., 1998) and temporal lobe (Papagno, 2001) regions. Thus, although patients with FLE may show greater overall impairment in metaphorical language, they may not be differentially impaired in terms of their ability to generate abstract interpretations relative to patients with TLE at the group level.

In addition to impaired abstraction, the FLE group tended to provide responses that were less accurate than those provided by controls ($p = .052$). However, inspection of subgroups revealed that the left FLE group was the only group significantly impaired in interpretation

accuracy. This finding suggests that the combination of impaired abstraction and accuracy led to the left FLE group achieving the poorest overall scores in proverb interpretation. These data are further supported by the increase in diagnostic accuracy, sensitivity, and specificity when only the left FLE patients were examined. Although some research has suggested that patients with frontal lobe damage provide accurate, but concrete, interpretations of nonliteral speech (Pearce et al., 1998), our data are in line with other studies indicating that the left frontal lobes are involved in other aspect(s) of cognition that could have compromised their accuracy, including poor discourse comprehension (Channon & Crawford, 2000) or reduced initiation (Novoa & Ardila, 1987). It is noteworthy that the left FLE and left TLE groups did not differ from one another in terms of estimated premorbid verbal IQ or their phonemic or category fluency. Therefore, impairments in general verbal ability or fluent word retrieval do not appear to account for the left FLE group's deficient accuracy.

In support of our second hypothesis, the FLE patients selected more of the concrete responses in the Multiple Choice condition than controls even when the correct, abstract response was available. This finding suggests that patients with FLE not only have difficulty generating abstract interpretations of proverbs, they also have difficulty appreciating metaphoric thought. This finding provides further evidence that the FLE group's poorer performance in proverb interpretation is not limited to difficulty with verbal production. Although the FLE group did not differ from the TLE group in the nature of their multiple choice selections at the group level, it is of note that patients with FLE selected concrete responses approximately 16% of the time, whereas patients with TLE and controls selected concrete responses 6% and 2% of the time, respectively. Furthermore, individual participant data demonstrated 75% specificity to FLE. Therefore, although errors in the Multiple Choice condition are not very frequent, they are more likely to be seen in patients with FLE when they do occur.

The present results also indicate that specific seizure-related variables predicted performances in both patient groups. As discussed, having a left-sided seizure focus was associated with (1) poorer accuracy in the FLE group and (2) poorer abstraction in the TLE group. The poorer performances associated with having a left-sided seizure focus is consonant with recent imaging studies demonstrating greater recruitment of left frontal and temporal lobe regions in the interpretation of nonliteral speech (Lee & Dapretto, 2005; Rapp et al., 2004; Stringaris, Medford, Giampietro, Brammer, & David, 2005) and with patient studies demonstrating greater impairments in patients with left compared to right hemisphere lesions for interpreting nonliteral or ambiguous speech (Channon & Crawford, 2000; Keil et al., 2005). Although some studies suggest that the right hemisphere may play an important role in processing metaphoric and figurative language (Anaki, Faust, & Kravetz, 1998; Bottini et al., 1994; Brownell, Simpson, Bihrle, Potter, & Gardner, 1990; Rinaldi, Marangolo, & Baldassarri, 2004; Shammi & Stuss, 1999; Winner & Gardner, 1977), recent investigations indicate that the understanding of metaphors under very demanding linguistic situations, such as when sentence comprehension is involved, may rely more on left hemisphere processes (Faust & Weisper, 2000). In support of this interpretation, earlier research suggesting a special role for the right hemisphere in metaphor interpretation often used picture-matching tasks that relied less on lexical-semantic processes (Rinaldi et al.,

2004; Winner & Gardner, 1977). Therefore, the recruitment of left versus right hemisphere regions in metaphor processing may be task specific (Faust & Weisper, 2000). That is, the degree to which left hemisphere regions are recruited may depend on the linguistic requirements of the task.

In addition to the side of the seizure focus, an early age of seizure onset predicted abstraction and overall performances in the TLE group, but not the FLE group. This finding is in line with research demonstrating a relationship between early age of seizure onset and degree of executive dysfunction in patients with chronic TLE (Hermann et al., 2002). Although the reason for this relationship is unclear, it has been proposed that patients with early onset TLE show generalized cognitive impairments and greater reductions in temporal and extratemporal white matter volume compared to those with late onset TLE (Hermann et al., 2002). Surprisingly, the duration of illness, number of anticonvulsant medications, and seizure frequency were not related to performances in the TLE group. These data suggest that there may be a sensitive stage of development related to verbal abstraction, and that the age at which seizures begin in TLE is more critical to abstract reasoning skills than is the overall duration of seizures in years.

The lack of a relationship between age of seizure onset and performances in the FLE group is not surprising given that few studies have found an association between seizure-related variables and degree of executive dysfunction in patients with FLE at the group level (McDonald, Delis, Norman, Tecoma, & Iragui, 2005b; Upton & Thompson, 1997). This lack of a relationship has been attributed to the fact that the complex, multi-stage maturation of the frontal lobes may obscure group differences when the location of frontal foci and ages of seizure onset are very heterogeneous in nature (Thatcher, 1991; Upton & Thompson, 1997). For example, Upton and Thompson found that an early age of seizure onset predicted motor, but not cognitive, performances in patients with right, but not left, FLE. Thus, the contribution of seizure-related variables, including age of seizure onset, is complex in patients with FLE and requires further attention at both the group and individual level.

Impaired Proverb Interpretation as the Result of Generalized Executive Dysfunction?

In this study we have demonstrated that patients with FLE show greater deficits in interpreting nonliteral language than matched control participants. This deficit likely reflects, in part, impaired verbal abstraction. However, there is some evidence from patient studies that successful proverb interpretation may also depend on a range of other executive skills (Sponheim et al., 2003). Channon and Crawford (2000) have suggested that patients with left anterior lesions produce literal, concrete interpretations of nonliteral speech that may be related to (1) a lack of cognitive flexibility needed to examine multiple aspects of a situation, (2) difficulties inhibiting more habitual, common interpretations in favor of more novel ones, and/or (3) a failure of inferential reasoning since only a *non* literal interpretation could link all of the relevant information together. In support of this multifactorial view of proverb interpretation, we found that performances on a proverbs test in patients with FLE were highly correlated with other measures of executive functioning, including cognitive flexibility, verbal fluency, response inhibition, and planning, whereas these relationships did not emerge in the TLE group. These results are also supported by research demonstrating

that WCST performance in FLE patients was associated with impairments on other tests of abstract reasoning, and that impaired WCST performance in TLE patients was associated only with impairments on non-executive measures (i.e., measures of new learning ability) (Giovagnoli, 2001). Taken together, these findings suggest that the mechanism of deficient proverb interpretation in FLE patients may be related to a generalized deficit in executive functions. In contrast, the integrity of executive functions in proverb interpretation may play less of a role in patients with TLE.

The Role of Executive Dysfunction Versus Remote Memory in Proverb Interpretation

It has been argued that older children and adults have stored representations of figurative meanings due to greater experience with nonliteral language and with specific proverbs (Thoma & Daum, 2006). Thus, it is possible that poor proverb interpretation in the FLE group may reflect impairment in remote memory rather than abstract reasoning. Although this possibility cannot be completely ruled out, there are two findings that make this explanation unlikely. As a post-hoc analysis, scores on the common (e.g., *you can't judge a book by its cover*) versus uncommon (e.g., *an old ox plows a straight row*) proverbs of the Proverbs Test were compared. These data demonstrated that patients with FLE obtained marginally higher scores for the common relative to the uncommon proverbs (mean scaled score = 7.7 and 6.5, respectively). However, it is of note that there are only three uncommon proverbs on this test and the mean scaled score difference was not statistically significant. A similar trend was noted for the TLE group. A second argument that poor proverb interpretation in the FLE group reflects poor executive functioning rather than impaired remote memory is demonstrated by the strong correlations between proverb scores and other measures of executive dysfunction in the FLE group. This pattern did not emerge in the TLE group. However, because no explicit tests of remote memory were administered to patients, the possibility that impaired remote memory contributed to poor proverb interpretation cannot be ruled out in our study.

CONCLUSION

In summary, the present study revealed several important findings with respect to impaired proverb interpretation in patients with FLE and TLE. First, our results highlight the importance of considering key disease-specific variables (i.e., side of seizure focus, age of seizure onset) and understanding how these variables contribute to impaired performances in each patient group. That is, in patients with FLE a left sided-seizure focus is the most critical factor for predicting impaired performances; whereas in patients with TLE a left-sided seizure focus and an early age of seizure onset lead to impaired abstraction ability. Second, our data demonstrate how individual participant analyses can provide additional diagnostic information that is often mitigated or obscured at the group level. This was particularly the case for patients with left FLE in the generation of correct, abstract interpretations. Finally, our data suggest that impaired proverb interpretation in patients with FLE is highly associated with impairments in other domains of executive functioning and may represent a more general, underlying deficit in executive functioning.

Despite the clinical value of our findings, there are some limitations of the study that should be addressed. First, it is possible that factors other than group membership, side of the seizure focus, and age of seizure onset led to impairments in one or both patient groups. Such factors may include the exact location of seizure onset and/or lesion location *within* the frontal lobes (i.e., orbitofrontal, mesial, or dorsolateral), the extent of seizure propagation, or the amount of interictal epileptiform activity. As with most studies of FLE patients, we were unable to evaluate the contribution of these factors to cognitive performances in our patient groups due to limitations of the available data. Second, as in most studies of patients with focal epilepsy, our study is limited by the relatively small sample size of the FLE and TLE subgroups. Finally, although we obtained statistically significant group differences in proverb interpretations, it is unclear whether or not patients with FLE and/or TLE have difficulty interpreting nonliteral language in day-to-day discourse, especially when additional contextual information (e.g., nonverbal cues) is available. Future research should examine the extent to which impaired performances in proverb interpretation and other measures of verbal abstraction predict actual difficulty understanding nonliteral aspects of conversational speech in patients with epilepsy and other neurological disease.

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Table 1

Demographic characteristics, epilepsy features, and neuropsychological test performances of the FLE. TLE, and Control groups (standard deviations are in parentheses)

	FLE (*N* = 22)	TLE (*N* = 20)	Controls (*N* = 23)
Age (years)	38.9 (9.8)	37.9 (8.9)	36.9 (9.9)
Education	13.8 (2.0)	13.5 (2.6)	13.8 (2.5)
Gender (females/males)	13/9	13/7	13/10
D-KEFS Letter Fluency	27.0 * (10.6)	29.2 * (13.5)	39.3 (10.1)
D-KEFS Category Fluency	32.5 * (8.2)	31.5 * (7.5)	39.3 (10.1)
WTAR standard score	99.3 (13.5)	102.8 (11.8)	—
Beck-Depression Inventory (raw score)	13.5 (9.4)	15.2 (8.6)	—
Age of seizure onset (years)	17.4 (12.1)	16.5 (14.2)	—
Duration of illness (years)	21.5 (11.8)	21.4 (12.9)	—
Seizure frequency (# per month)	5.5 (7.3)	7.5 (9.3)	—
Number of anticonvulsant medications	1.9 (.75)	1.5 (.69)	—

* Group mean is statistically different from that of controls at $p < .05$.

Table 2

Examples of (A) potential responses and scoring of the first proverb in the Free Inquiry condition, and (B) the four alternative meanings of the first proverb from the Multiple Choice condition

	Accuracy rating	Abstractness rating
Proverb #1: *You can't judge a book by its cover*		
(A) Free Inquiry		
First impressions can be deceiving	Accurate	Abstract
You really don't know if a book is going to be good until you read it	Accurate	Concrete
All people are created equal	Inaccurate	Abstract
It's fun to read books	Inaccurate	Concrete
Proverb #1: *You can't judge a book by its cover*		
(B) Multiple Choice		
1. First thoughts about someone can be wrong	Correct	Abstract
2. A person should read a novel before deciding if it is good	Correct	Concrete
3. You can't buy a book that covers every subject	Incorrect	Phonemic
4. The early bird catches the worm	Incorrect	Unrelated

Table 3

Proverb test performances of the FLE, TLE, and Control groups (standard deviations are in parentheses)

	FLE (*N* = 22)	TLE (*N* = 20)	Controls (*N* = 23)
Proverbs Free Inquiry scaled score	6.5* (3.6)	8.4 (3.8)	10.4 (2.8)
Proverbs Accuracy scaled score	7.0^{+} (3.6)	9.2 (3.2)	10.3 (3.3)
Proverbs Abstraction scaled score	6.0* (4.4)	7.1* (4.1)	10.1 (2.8)
Proverbs Multiple Choice cumulative percentile rank	60.0* (46.3)	68.8 (42.6)	80.3 (38.3)
Abstract selections % of total	78.2* (0.3)	90.1 (0.2)	94.1 (0.1)
Concrete selection % of total	15.8* (0.2)	0.06 (0.1)	0.02 (0.1)
Phonemic selections % of total	0.05 (0.1)	0.02 (0.1)	0.1 (0.1)
Unrelated selections % of total	0.02 (0.1)	0.01 (0.1)	0.0 (0.0)

Group mean is statistically different from that of controls at $p < .05$* and $p < .06^{+}$.

Table 4

Mean scaled scores for patient subgroups and Spearman correlations among disease-related variables and Proverbs Test performances in the FLE and TLE groups

	Group	Accuracy	Abstraction
Side of seizure onset[#]			
	Left FLE	6.1 (3.1)	5.5 (4.1)*
	Right FLE	9.0 (3.1)	8.4 (4.6)
	Left TLE	8.5 (3.1)	4.8 (3.9)*
	Right TLE	10.6 (2.9)	10.3 (2.3)
Lesion status[#]			
	Lesional FLE	7.0 (3.7)	5.4 (4.4)
	Nonlesional FLE	7.6 (3.3)	7.0 (4.5)
Age of seizure onset			
	FLE	.235	.253
	TLE	.503*	.378+
Duration of illness (in years)			
	FLE	−.211	−.298
	TLE	−.338	−.144
Seizure frequency (number per month)			
	FLE	.215	.005
	TLE	.023	.138
Number of anticonvulsant medications			
	FLE	−.238	−.388
	TLE	−.258	−.272

+ $p < .10$,

* $p < .05$.

Lesion status was not included as a variable in the TLE group analysis because all TLE patients showed MTS on MRI with no evidence of dual pathology.

[#] Mean scaled scores (and standard deviations) are shown for each FLE and TLE group.

Table 5

Pearson correlations between the Proverbs Test overall score and scores on other measures of executive functioning in the FLE and TLE groups. All scores are age and education adjusted

	Proverb free inquiry	
	FLE	**TLE**
Trails Number–Letter Sequencing[#]	.779**	.041
Stroop Color–Word Interference[#]	.573**	.262
Letter Fluency	.673**	.296
Category Fluency	.599**	.371
Tower Test	.470*	.392

*$p < .05$,

**$p < .01$.

[#]Higher values reflect better performances.