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Influence of anxiety on memory performance in temporal lobe epilepsy

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Abstract

This study examined the degree to which anxiety contributed to inconsistent material-specific memory difficulties among 243 temporal lobe epilepsy patients from the Multisite Epilepsy Study. Visual memory performance on the Rey Complex Figure Test (RCFT) was lower for those with high versus low level of anxiety, but was not found to be related to side of TLE. Verbal memory on the California Verbal Learning Test (CVLT) was significantly lower for left than right TLE patients with low anxiety, but equally impaired for those with high anxiety. These results suggest that we can place more confidence in the ability of verbal memory tests like the CVLT to lateralize to left TLE for those with low anxiety, but that verbal memory will be less likely to produce lateralizing information for those with high anxiety. This suggests that more caution is needed when interpreting verbal memory tests for those with high anxiety. These results indicated that RCFT performance was significantly affected by anxiety and did not lateralize to either side,

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Disclosure

All authors have full disclosure of any conflicts of interest. We confirm that we have read Epilepsy and Behavior's guidelines for ethical publications and that our report is consistent with these guidelines.

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regardless of anxiety level. This study adds to the existing literature which suggests that drawing-based visual memory tests do not lateralize among TLE patients, regardless of anxiety level.

Keywords

Anxiety; Temporal Lobe Epilepsy; Visual Memory; Verbal Memory

1. Introduction

For more than 40 years [1–5], neuropsychologists have administered memory tests to epilepsy patients with the belief that right temporal mesial lobe epilepsy (RTLE) was associated with nonverbal memory impairments and left temporal mesial lobe epilepsy (LTLE) was associated with the verbal memory deficits. Numerous studies have supported the association between LTLE and verbal memory [6–12]. However, the association between RTLE and visual memory performance has been less consistent, with larger studies typically failing to find this relation [8, 13–15].

These inconsistent findings might be due, in part, to the use of visual stimuli which can be verbally encoded. This is supported by studies suggesting that tests using material that is more difficult to verbalize (e.g. dot locations or random patterns) typically revealed stronger associations between visual memory performance and RTLE or right hippocampus resections [16–19] than tests using abstract designs [20–22]. Functional neuroimaging studies also support this by indicating that the type of stimuli (e.g., line drawings) often used in visual memory tests are affected by verbal interference paradigms and reflect fMRI activation in verbal areas of the brain [23]. In addition, functional reorganization in chronic epilepsy may contribute to the unaffected temporal lobe taking over both verbal and visual memory functions [24].

However, psychological variables may also contribute to the inconsistent association of visual memory with the affected temporal lobe. In reviewing the literature, it appears that anxiety, in particular, has had a disproportionate impact on visual memory but not verbal memory [25–27]. Specifically, obsessive compulsive disorder [25–27] and more generalized agoraphobia [26] were associated with lower visual memory performance on the Rey Complex Figure Test (RCFT), but not verbal memory. Indeed, out of multiple articles reviewed, we only located one where verbal list learning performance was lower among individuals with anxiety disorders [28]. Depression on the other hand, has appeared to have more general effects on cognition [29, 30], rather than specifically impacting visual memory. Thus, it is possible that anxiety could have contributed to inconsistent findings among drawing-based visual memory tests whereas prior research does not suggest the same relationship between depression and visual memory.

The reason that anxiety results in disproportionately lower visual than verbal performance may be related to different task demands among these memory tests. Specifically, drawing-based visual memory tests require more fine motor control, organization and planning, and processing speed demands than verbal measures [31, 32]; and these same functions appear to be problematic among individuals with anxiety disorders [33, 34]. Furthermore, most visual memory tests have one exposure to test stimuli whereas verbal list learning tests include repeat exposures. This makes such tests susceptible to fluctuations in attention and working memory which tend to be affected by anxiety [35, 36].

The importance of properly assessing verbal or visual memory goes beyond providing information about whether test results are consistent with right or left TLE, and is an important part of predicting surgical outcomes. Several studies have found that verbal list

learning memory was as good, and in some cases a better predictor of postoperative verbal memory than intracarotid amobarbital testing whereas this has not been found among visual measures. Those with problematic pre-surgical verbal memory were less likely to experience post-surgical declines, whereas those with higher presurgical verbal memory were more likely to experience a significant decline in verbal memory [15, 37, 38]. The problems with consistent visual memory assessment in TLE have not yet made such a prediction possible [8, 13–15]. Thus, it would certainly be important to identify whether non-neurological variables, such as anxiety, might affect pre-surgical visual memory results. Furthermore, it would be helpful to determine whether taking into account level of anxiety may result in drawing-based visual memory tests being more useful for such predictions.

1.1 Current Study

Poor performance on verbal list learning tests such as the CVLT appears to be fairly consistent among patients with LTLE. Anxiety has not been consistently associated with list learning performance; however, this has not been studied in TLE. Drawing-based visual memory performance, such as the RCFT, has not been consistently associated with RTLE, but does seem to be affected by anxiety. However, the role of anxiety and how it may affect lateralizing information on visual memory tests has not been studied among epilepsy patients.

In the current retrospective study, we examined the relations between anxiety and performance on verbal (CVLT) and visual (RCFT) memory in left and right TLE patients. We expected that high levels of anxiety would be associated with lower performance on the RCFT, whereas anxiety would not mediate verbal memory. We also anticipated that verbal memory would be sensitive to LTLE, but did not expect the RCFT to be sensitive to RTLE. However, since anxiety levels did not appear to be taken into account in prior research, we tentatively hypothesized that there may be a potential relationship between RCFT and RTLE when limited to patients with low levels of anxiety.

2. Methods

2.1 Participants

This was a retrospective analysis of 243 patients who had undergone neuropsychological testing as part of a pre-surgical evaluation for patients with TLE. All patients were part of the Multicenter Study of Epilepsy Surgery (MSES). The MSES is a longitudinal study examining the outcomes of surgery at seven epilepsy centers in the United States of America. In-depth discussion of patient recruitment, inclusion and exclusion criteria, and other characteristics are discussed elsewhere [39, 40]. In brief, however, patients had to show evidence of medically refractory epilepsy with seizures that impaired consciousness on at least a monthly basis. All patients underwent a presurgical evaluation that was consistently performed across sites [41] and included EEG, PET, MRI, neuropsychological testing, and intracarotid amobarbital testing.

To be included in the analysis patients had to have (1) been clearly identified with either right or left mesial TLE, (2) undergone either right or left anterior temporal lobectomy following their pre-surgical evaluation, (3) been identified as left language dominant according to intracarotid amobarbital testing, and (4) remained seizure free for two years in order to improve the likelihood that the pre-surgical evaluation correctly lateralized the epileptogenic focus. Exclusion criteria included additional neurological disorders which would make the etiology for their cognitive difficulties unclear (e.g., history of moderate to severe TBI, substantial stroke outside of the surgical area, and similar neurological disorders). All study procedures were approved from each institutions' human subjects

committee review boards. The current analyses were limited to demographics, side of mesial TLE; pre-surgical intellectual functioning, memory, and self-report anxiety functioning.

2.2 Measures

Estimation of overall intellectual functioning was based on the Full Scale IQ score provided by the Wechsler Adult Intelligence Scale, Revised Edition, WAIS-R [42]. We also examined the Verbal and Performance IQ scores since these may be differentially affected by side of epilepsy. We assessed visual memory using the Rey Complex Figure Test, RCFT [43, 44] in which the examinee copies a complex design, and then draws it from memory after short and long delays. We used the age adjusted T-Scores ($M = 50$, $SD = 10$) for the Immediate and Delayed Free Recall which are in the published manual (Meyers & Meyers, 1995).

We assessed verbal list learning memory with the California Verbal Learning Test, CVLT [45]. The CVLT has been demonstrated efficacy in identifying LTLE in previous studies [6, 46]. Though one large study [12] recently found that the Rey Auditory Verbal Learning Test, may be more sensitive to left temporal lobe epilepsy than the CVLT; this was based only on the raw scores from learning trials, not the delayed trials. Also, the Rey Auditory Verbal Learning Test also has some problems with its normative data in some age ranges. For example, individuals who are 60 can only get one word correct on the long delay, but still get a scaled score of 5 [47]. Also, the AVLT normative data was not available at the time this study began toward the end of the 1990s). Thus, the CVLT has received ample support for use in this study, and had more useful normative data at the time we started this study. In this particular study, we used the age adjusted Z-scores ($M = 0$, $SD = \pm 1$) for the short and long delay that are provided in the published manual [45].

We assessed anxiety with the Beck Anxiety Inventory, BAI [48]. The BAI asks the patient to indicate the prevalence and severity of general anxiety symptoms over the past week on a 0 to 3 scale. Thus, this is a not a state anxiety scale, but measures more longstanding anxiety symptoms. The BAI manual [48] indicates the following levels: scores of 8–15 indicate mild anxiety; scores of 16–25 indicate moderate anxiety, and scores of 26–63 suggest severe anxiety. In deciding how to use these scores, we noticed that the literature suggested that the relationship between anxiety and memory performance has often been overstated due to a non-normal distribution where a small set of individuals with severe problems skew the results [49]. Indeed, we examined the BAI score distribution and noticed it was not normally distributed. Specifically, a large group of patients performed within the range of 0–15 which was the modal range; however, there was a slightly lower secondary mode among the scores in the 20s with scores extending to the highest range of the test. This distribution and prior research suggested that dividing level of anxiety into two discrete variables would be a better method of analysis than examining it as a continuous variable in a regression. Thus, we placed patients in the mild anxiety range and lower into the “low” range while those with moderate to high anxiety were placed in the “high range.”

2.3 Statistical Analyses

We used the Statistical Package for Social Sciences (SPSS), version 19 for all data analyses [50]. The following were conducted to determine if there were any demographic or intellectual variables which needed to be controlled when examining the hypotheses. Chi Square analyses were used to examine the relationship between categorical demographic variables (gender and ethnicity) with independent variables (including side of TLE and level of anxiety). One-way analyses of variances (ANOVAs) were used to examine the relationships between level of anxiety and age; level of anxiety and age of first seizure; level of anxiety and education; epilepsy side and age, epilepsy side and age of first seizure, epilepsy side and education. A two by two (side of TLE x level of anxiety) multivariate

analysis of variance (MANOVA) was conducted to examine group differences on the intellectual functioning variables (Full Scale IQ, Verbal IQ, and Performance IQ).

To test the primary hypothesis (the effects of side of TLE and level of anxiety on memory performance), we performed a two by two (side of TLE x level of anxiety) MANOVA using the age adjusted RCFT T-Scores and CVLT Z-Scores for the short and long delay scores as dependent variables. To determine whether any observed main effects or interactions were specific to visual or verbal memory scores, we did two-way ANOVAs (side of TLE and level of anxiety) for each of the 4 dependent variables using a 0.0125 Bonferroni correction. Finally, within the high and low anxiety groups, we performed one-way (side of TLE) MANOVAs to determine the degree to which laterality information was generally associated with visual or verbal memory performance when separately examining those with low or high levels of anxiety. We followed these analyses with one-way (side of TLE) ANOVAs on the 4 dependent variables (using a 0.0125 Bonferroni correction) to examine the degree to which side of TLE was associated with specific visual or verbal memory subtest scores when only examining those with either low or high levels of anxiety. Since there was a lower number of subjects within the high and low anxiety groups, we used Levene's Test of Equality of Error Variances, and examined the observed power to determine if sample size and variance were likely to impact the results. We would like to point out that our choice of analyses were based on statistical reasons (memory test scores were continuous but anxiety and side of epilepsy were categorical), and also practical reasons. The use of MANOVA and follow-up analyses allowed us to examine mean score differences using standardized scores. This allows the reader to directly see the clinical relevance among the results, and also apply such findings to clinical practice.

3. Results

3.1 Participant Group Information

A total of 243 participants (137 Females and 106 Males) completed all the measures required for inclusion in this study. The ethnic breakdown included 86% non-Hispanic White, 9 % African American, 3% Hispanic, 1% Native American, and 1% Asian. There were a total of 131 with LTLE, 124 with RTLE; 188 had low anxiety and 55 had high anxiety.

Results of the Chi-square analyses and one-way ANOVAs indicated that the right and left TLE groups, and the high and low anxiety groups did not differ in terms of age, age of first seizure onset, gender, ethnicity, and level of education (all $p > .05$). Table 1 shows the number of patients in the high and low anxiety, and left and right temporal lobe epilepsy groups.

The two-way MANOVA did not reveal any differences on intellectual functioning measures according to level of anxiety or side of TLE. Means and standard deviations for age, age of first seizure, education and WAIS-R variables, separated by side of TLE and level of anxiety, are presented in Table 2.

3.2 Anxiety, Temporal Lobe Epilepsy Side, and Memory Performance

The two-way MANOVA for the primary analysis revealed overall differences on the dependent memory variables according to TLE side (Wilk's $\Lambda = .96$, $F(4, 236) = 2.51$, $p = .04$) and according to level of anxiety (Wilk's $\Lambda = .95$, $F(4, 236) = 2.51$, $p = .01$). However, there was no significant interaction between TLE side and level of anxiety on the dependent variables. Follow-up two way ANOVAs with a 0.0125 level Bonferroni correction indicated that those with LTLE had lower CVLT Short Delay Recall ($F(1, 239) = 8.81$, $p = .003$ and CVLT Long Delay Recall scores ($F(1, 239) = 9.36$, $p = .002$) when compared to RTLE,

whereas there were no relationships between anxiety and CVLT scores. On the other hand, there were no differences on RCFT variables according to side of TLE, but high anxiety was associated with lower RCFT Immediate ($F(1, 239) = 8.86, p = .003$) and Long Delay ($F(1, 239) = 11.89, p = .001$) Recall Scores when compared to those with low anxiety. There were no significant interactions between side of TLE and level of anxiety on the dependent variables. The means and standard deviations of the dependent variables as function of side of surgery and level of anxiety are presented in Table 3.

3.3 Does Level of Anxiety Influence Laterality Findings?

Given the significant relation between anxiety and RCFT performance, we further explored whether the RCFT would provide useful laterality information when restricting the analyses to those with low levels of anxiety. In order to do this, we analyzed the low and high anxiety groups separately. For each anxiety group, we then conducted a one-way MANOVA with side of TLE as the fixed factor and the four memory scores as dependent variables. Differences were found among the dependent variables according to TLE side for those with low anxiety, Wilk's $\Lambda = .95, F(4, 50) = 2.51, p = .01$, but not for those with high anxiety. As a result, follow-up univariate ANOVAs were conducted for the low anxiety group with the 0.0125 Bonferroni correction. The results did not reveal any differences on the RCFT according to side of TLE for low anxiety. However, the low anxiety group with LTLE performed significantly lower than the RTLE group on the CVLT Short, $F(1, 186) = 17.05, p = .001$, and Long, $F(1, 186) = 14.09, p = .001$, Delay scores. The dependent variables did not significantly differ across conditions according to Levene's Test of Equality of Error Variances. The means and standard deviations of the dependent variables, level of significance, effect sizes, and observed power as function of side of surgery and level of anxiety are on Table 4.

4. Discussion

In this study, we identified level of anxiety as a potential confound when using memory tests to lateralize the seizure focus in TLE. Specifically, we found that the CVLT provided useful laterality information for those with low anxiety; however, it was not a useful laterality measure for those with high anxiety. This suggests caution when interpreting verbal memory test scores of patients with high levels of anxiety, yet allows for greater confidence in verbal memory scores of patients with low anxiety levels. This is important not only for preoperative lateralization, but also in predicting postoperative changes since those with higher levels of pre-surgical verbal memory are more likely to experience a decline following surgery [15, 37, 38]. Thus, it would be important to determine whether low preoperative verbal memory scores truly reflect level of functioning and/or are confounded by high anxiety.

These results also provide useful information about interpreting drawing-based visual memory tests such as the RCFT, and what types of visual memory tests to avoid in epilepsy patients if laterality information is being sought. Specifically, we found that RCFT performance was significantly associated with level of anxiety, but not side of TLE. Furthermore, this lack of sensitivity to side of TLE remained even when only examining those with low levels of anxiety. These findings suggest that the RCFT specifically appears affected by level of anxiety. Though one may be tempted to generalize this finding to suggest that drawing-based visual memory on a variety of measures are lowered by level of anxiety, it is important to note that this study only specifically examined the relationship between RCFT and level of anxiety. Furthermore, this particularly visual memory test requires a greater degree of organization than simpler drawings present on other drawing-based visual memory tests.

However, there have been multiple large studies, and meta-analyses which have demonstrated that drawing-based visual memory tests do not typically differentiate side of TLE. Thus, while further examination of drawing tests among patients with anxiety is needed, this study does add to the already existing literature which has repeatedly suggested that a variety of drawing-based visual memory tests were insensitive to RTLE in large studies including the Brief Visuospatial Memory Test, Revised [13], and Visual Reproduction from the Wechsler Memory Scales [21]. Furthermore, there appears to be a lack of sensitivity of line designs to RTLE even when drawing is not required such as on the Visual Spatial Learning Test [22]. A detailed discussion of visual memory in TLE is beyond the focus of this article, however, alternative stimuli with some empirical support includes dot locations on an asymmetrical circle array [19], dot locations on a selective reminding test [16], and faces [20, 51]. Regardless, these and other studies suggest that alternatives to drawing-based should be further explored among epilepsy patients.

Though this study did not explicitly examine the underlying reasons that memory, particularly visual memory, may be lower among those with high anxiety, there has been some prior research that may aid in our understanding. For example, motor skills, processing speed, and organization weaknesses have been found to be lower among some patients with OCD [33, 34] which could clearly impact one's ability to draw complex designs from memory. General levels of anxiety have been associated with reduced visual spatial working memory on a block tapping tasks, but not on phonological working memory tasks in some studies [35, 36]; although other studies have found that auditory working memory may be lower among those with anxiety [52]. Anxiety has also been associated with lower performance on color-word interference and sustained auditory attention tests [53]. Thus, it would appear that difficulties with working memory and attention secondary to anxiety may be part of the reason for lower performance on these memory tests.

Another possibility is that higher levels of anxiety according to the BAI [48] may also reflect TLE associated difficulties. Some of the items on the BAI ask about physiological anxiety symptoms that may be associated with auras and/or seizures (e.g., "numbness or tingling, fear of the worst happening, shaky, indigestion or discomfort in the abdomen, etc). Along similar lines, a recent review article [54] pointed out some shared physiological characteristics of anxiety and TLE such as anomalies regarding GABA, white matter connectivity, and the role of limbic system structures. Thus, it is possible that the lower scores among those with high anxiety could be partly related to the nature of their epilepsy, although there is a paucity of empirical study in this area. We also specifically examined age of first seizure to determine if level of anxiety could have been secondary to a more severe and prolonged seizure disorder, but we did not find a relationship between these variables. Regardless of the etiology, however, these results do suggest that caution needs to be taken when interpreting memory tests among those with high levels of anxiety.

This study does have some limitations. We used data from seven different sites. However, the tests were administered by trained individuals and all the RCFT protocols were reviewed and scored by one neuropsychologist (M.W.). Thus, while inter-rater reliability variations can contribute to drawing-based test variability [31], the use of one rater should reduce such variation. Furthermore, the use of multiple sites is a strength in that it provides for a larger than typical sample of patients with mild scoring variations likely disappearing due to the large size of the sample. Finally, prior research indicated that there was a high degree of inter-rater reliability for procedures among the different sites[41], reducing the likelihood that site specific differences impacted test results.

There were also some limitations when interpreting the verbal memory results among those with high anxiety. Specifically, there was a much smaller sample size within the high

anxiety than low anxiety group. Furthermore, the smaller sample size may have contributed to the much lower observed power in the high anxiety group (ranging from .225 to .303) than the low anxiety group (ranging from .962 to .984). Thus, it is possible that significant differences may have emerged between the RTLE and LTLE groups on the CVLT in the high anxiety condition with a larger sample size. However, direct examination of the means and standard deviations tended to reduce this likelihood from a clinical perspective. Specifically, the CVLT Scores for the LTLE group for both the high and low anxiety conditions were generally around a mean Z-score of -2 and slightly lower among those with high anxiety. On the other hand, low anxiety group RTLE CVLT scores were around a mean Z-score of -0.95 , whereas the high anxiety RTLE CVLT mean Z-scores ranged between -1.6 to -1.76 . Furthermore, the standard deviations were nearly identical for the CVLT regardless of anxiety level or TLE side. Thus, while the CVLT was fairly consistent for the LTLE group regardless of level of anxiety, subjects with high anxiety but RTLE had scores that were closer to the LTLE group than the low anxiety RTLE group. Thus, while one could argue that a larger sample size for the high anxiety group may have produced significant differences, the available evidence suggests that this would not be likely given the current means and standard deviations. Thus regardless of the difference in sample sizes, these results suggest that one needs to interpret the CVLT more cautiously among patients with high levels of anxiety.

Another limitation is that the BAI asks about general levels of anxiety; it does not differentiate among specific types of anxiety disorders. It is possible that different types of anxiety disorders had differential impact on memory performance. For example, Obsessive Compulsive (OCD) has been repeatedly associated with lower RCFT performance [25–27], whereas there have been less consistent findings among more generalized forms of anxiety [25, 26]. On the other hand, the BAI has few symptoms related to OCD and typically addresses symptoms more typically associated with generalized anxiety and similar disorders [48]. Thus, it is unlikely that the majority of patients with high anxiety specifically had OCD; however, it is something worth considering in future studies. Regardless, this is a relatively minor limitation that should not detract from the point that anxiety should be carefully considered when interpreting memory test results.

4.1 Conclusions

These findings suggest that we can place much more confidence when interpreting verbal memory results for those with low anxiety than those with high anxiety. This is especially important in that pre-surgical verbal memory has been found to be a useful predictor of post-surgical verbal memory decline. These results also suggest, however, that drawing-based visual memory tests are poorly associated with either side of TLE and that stimuli with complex designs such as the RCFT may be significantly affected by level of anxiety. Furthermore, this study adds to the existing literature that non-drawing-based visual memory tests are needed if we are going to be able to consistently predict post-surgical visual memory decline. Finally, these results do also suggest the importance of taking extra time to build rapport with those patients who report anxiety and possible ease some of their state anxiety that may be affecting test performance.

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Appendix

Table 1

Localization Side by Level of Anxiety

Side	Low Anxiety	High Anxiety
Left	n = 101	n = 30
Right	n = 88	n = 25

Table 2

Means and Standard Deviations for Demographic Variables

Variable	Side of TLE				Level of Anxiety			
	LTLE		RTLE		Low Anxiety		High Anxiety	
	M	SD	M	SD	M	SD	M	SD
Age	38.5	10.6	39.0	11	38.9	11	38.1	10
Age of Onset	14.3	10.8	15.7	12.7	14.8	11.8	15.4	11.6
Education	13.6	2.4	13.4	2.4	13.7	2.4	12.9	2.5
Full Scale IQ	89.7	10.9	93.3	12.2	92.1	12.3	88.8	8.7
Verbal IQ	89.6	11.7	94.3	12.9	92.2	12.9	90.2	10.8
Performance IQ	91.1	12	93.6	13.0	93.3	13.1	89	9.9

Table 3

Means and Standard Deviations for Memory Variables

	<i>Side of TLE</i>				<i>Level of Anxiety</i>			
	LTLE		RTLE		Low Anxiety		High Anxiety	
	M	SD	M	SD	M	SD	M	SD
CVLT Short Delay ^a	-2.0	1.7*	-1.1	1.6*	-1.5	1.8	-1.9	1.5
CVLT Long Delay ^a	-2.1	1.8*	-1.3	1.7*	-1.6	1.8	-2.1	1.7
RCFT Immediate ^b	32.5	13.2	32.7	12.4	33.9	13.2*	27.9	10.1*
RCFT Long Delay ^b	31.2	12.7	31.0	11.9	32.6	12.6*	25.9	9.9*

^aThese scores refer to the age adjusted Z-Scores in the California Verbal Learning Test manual.^bThese scores refer to the age adjusted T-Scores in the Rey Complex Figure Test manual.* $p < .01$ **Table 4**

Means and Standard Deviations for Memory, Split into Low and High Anxiety

		<i>LTLE</i>		<i>RTLE</i>		p	η^2	α^{obs}
		M	SD	M	SD			
CVLT Short Del ^a	Low Anx.	-2.0	1.8	-0.9	1.7	<.001	.084	.984
	High Anx.	-2.1	1.7	-1.6	1.3	NS	.027	.225
CVLT Long Del. ^a	Low Anx.	-2.1	1.7	-1.1	1.7	<.001	.070	.962
	High Anx.	-2.4	1.9	-1.7	1.5	NS	.039	.303
RCFT Immed. ^b	Low Anx.	34.5	13.7	33.3	12.65	NS	.002	.090
	High Anx.	25.9	8.7	30.4	11.3	NS	.048	.363
RCFT Long Del. ^b	Low Anx.	33.2	13.1	31.8	11.9	NS	.003	.115
	High Anx.	24.4	8.2	27.9	11.4	NS	.031	.303

^aThese scores refer to the age adjusted Z-Scores in the California Verbal Learning Test manual.^bThese scores refer to the age adjusted T-Scores in the Rey Complex Figure Test manual.

Anx. = Anxiety

 η^2 = partial eta squared is an estimate of effect size α^{obs} = alpha observed, equals the observed power

Highlights

- Examines the degree to which anxiety mediates pre-surgical visual and verbal memory performance for 243 temporal lobe epilepsy patients.
- Verbal memory differentiated LTL from RTL epilepsy with low but not high anxiety.
- Visual memory did not differentiate LTL from RTL epilepsy, regardless of anxiety.
- Visual memory was associated with level of anxiety
- We conclude that memory results should be cautiously interpreted for patients with high anxiety.