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I, **Shawna N Bonner**, hereby submit this original work as part of the requirements for the degree of Master of Arts in Psychology.

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Social cognition and psychosocial functioning in temporal lobe epilepsy

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Social cognition and psychosocial functioning in temporal lobe epilepsy

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Abstract

The goal of this study was to investigate the social cognitive domains of facial affect processing and emotional intelligence in patients who had undergone anterior temporal lobectomy (ATL) for the treatment of medically intractable temporal lobe epilepsy. It was hypothesized that patients who underwent right ATL would perform more poorly than left ATL patients on measures of facial affect processing and emotional intelligence. Additionally, we expected poorer performance on measures of social cognition to predict poorer psychosocial functioning. Participants were sixteen individuals who had undergone ATL at the University of Cincinnati Medical Center. They completed a facial affect processing battery, a performance based emotional intelligence test, neuropsychological measures (memory, attention executive ability, and confrontation naming), and self-report questionnaires of quality of life and psychosocial functioning. Data from 16 participants (8 right ATL; 8 left ATL) were analyzed. Participants with right ATL were less accurate than participants with left ATL in their ability to identify the presence and rate the intensity of emotions in facial expressions. The right ATL group performed more slowly than the left while comparing the relative intensity of emotions depicted in two faces and when rating the intensity of the emotional valence of facial expressions ($p < .10$ for all comparisons). Despite their slower performance, the right ATL group was significantly more accurate than the left ATL group in their ability to compare the relative intensity of emotions depicted in two faces ($p < .10$). Poorer ability to rate the relative intensity of emotions depicted in faces and to incorporate one's own emotions into decision making were significantly related to poorer self-reported functioning on multiple domains of quality of life and psychosocial functioning, all $p < .05$.

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Chapter 1

Introduction

More than half of all patients with epilepsy have partial-onset seizures, meaning that their seizures begin in a focal area of the brain. Temporal lobe epilepsy (TLE) is the most common form of partial-onset illness. Epilepsy treatment is continuous and expensive, even for those patients who experience seizure remission, with a national estimated cost of \$12.5 billion for the year 2000 (Begley, et al., 2000). In addition to their seizures, patients with TLE commonly experience cognitive and functional deficiencies. The present study examined the domain of social cognition in patients with temporal lobe epilepsy and investigated whether deficiencies in this domain are related to functional outcomes in these patients. The following review of the literature will provide background on general neuropsychological functioning, social cognition, and functional outcomes in patients with TLE.

Neuropsychological Functioning in TLE. Patients with TLE typically demonstrate clear neuropsychological deficits which tend to be material-specific depending on seizure lateralization. There is strong evidence that patients with left TLE, when compared to patients with right TLE, perform more poorly on verbal learning, verbal memory, and expressive language tasks (Loring, 1997; Moore & Baker, 2002). Furthermore, as a group, patients with TLE are more likely than the general population to experience impairments in executive function and working memory (Oyegbile, et al., 2004; Stretton & Thompson, 2011). Longer disease duration, lower education level, higher age, increased hippocampal atrophy, and the use of certain antiepileptic medications are all predictors of poorer neuropsychological functioning in patients with TLE (Hermann, et al., 2006; Oyegbile, et al., 2004; Elger, Helmstaedter, & Kurthen, 2003).

Social Cognition. In addition to their core neuropsychological deficits, there is growing evidence that certain patients with TLE demonstrate impairments in social cognition. There are limited but provocative reports that recognition of affect (i.e., the ability to recognize emotions in others) is impaired in some individuals with epilepsy. Patients with TLE who have not yet undergone epilepsy surgery show impairments in affect recognition from faces and voices (Bonora, et al., 2011). In addition, those with right TLE have consistently performed more poorly than patients with left TLE and controls on tasks requiring the recognition and discrimination of emotions from facial expressions, with left TLE patients as a group performing in the normal range (Benuzzi et al., 2004; Meletti, et al., 2003).

In addition to seizure lateralization, earlier age of seizure onset and the presence of mesial temporal sclerosis (MTS) are also associated with facial affect processing deficiencies (Benuzzi, et al., 2004; McClelland, et al., 2006; Meletti, et al., 2003). Mesial temporal sclerosis occurs in a subset of patients with TLE and is characterized by neuronal cell loss and development of scar tissue in hippocampal and amygdalar regions. The finding that MTS predicts facial affect processing is consistent with extensive evidence that the amygdala is critical to affective processing abilities (e.g., Adolphs, Baron-Cohen, & Tranel, 2002; Liberman, 2010; Phillips, Drevets, Rauch, & Lane, 2003) and that damage to the right amygdala is related to impaired fear recognition (Adolphs, Tranel, & Damasio, 2001; McClelland, et al., 2006; Meletti, et al., 2003). Consistent with this line of reasoning, patients who have undergone right anterior temporal lobectomy (which includes removal of the hippocampus and amygdala) show more impairment than patients with left anterior temporal lobectomy and healthy controls in the recognition of a range of facial expressions (Adolphs, Tranel, & Damasio, 2001).

Functional Outcomes. Psychosocial functioning refers to an individual's ability to interact with others and to function effectively in society (Lam, Filteau, & Miley, 2011). Individuals with epilepsy often struggle more than their neurologically healthy peers to function well in everyday settings such as significant relationships, family role functioning, and work roles (Baker, 2002; McCagh, Fisk, & Baker, 2009). Within the epilepsy literature, however, these aspects of functioning are studied almost exclusively from the perspective of quality of life (QOL). The World Health Organization defines QOL as "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns (WHOQOL Group, 1994)." Although QOL instruments are useful when considering patient well-being, they do not capture the breadth of an individual's ability to interact with others and function effectively in society. In particular, the Quality of Life in Epilepsy Inventory (QOLIE; Cramer et al., 1998) is a widely used epilepsy-specific measure of QOL which addresses multiple domains including overall emotional well-being and social functioning; however, it does not address specific areas of psychosocial functioning, such as work role or parental functioning. For example, the QOLIE-31 includes only a single question about work, on which the respondent is asked to rate how much he or she is bothered by epilepsy-related work restrictions.

Psychosocial functioning in patients with TLE has not been well studied with standardized measures that capture the breadth of the individual's ability to interact with others and function effectively in society. One standardized measure of psychosocial function is the Social Adjustment Scale, Self-Report (SAS-SR; Weissman, 1999). The SAS-SR includes an entire section on work role functioning, on which the respondent is asked to rate how often he or she has had different types of difficulties in the primary work role, whether that be employment,

school, or homemaking. Such an instrument allows one to assess not only how the respondent feels about certain areas of his or her function, but also how effectively he or she is functioning in society.

It is not entirely clear from the literature how measurements of psychosocial functioning and quality of life are related. A careful review of the literature revealed a single study (Gois, et al., 2011) that has investigated the relationship between psychosocial functioning (as measured by the Social Adjustment Scale – Self-Report and QOL in patients with TLE, with the finding that psychosocial functioning was at least partially independent of QOL. To summarize, there is a limited amount of information about psychosocial functioning in this population that has been measured with standardized instruments other than QOL questionnaires, and it is unknown which demographic, disease or cognitive variables will predict aspects of psychosocial functioning that are not captured by QOL measures.

A number of factors are related to poorer overall QOL in this population, including greater seizure severity and frequency, more depressive symptoms, and limitations on employment and driving (Jehi, Tesar, Obuchowski, Novak, & Najm, 2011). There is strong evidence that poorer neuropsychological performance is a predictor of lower QOL in patients with epilepsy (Breier, et al., 1998; Giovagnoli & Avanzini, 2000; Perrine, et al., 1995); however, interpretation of this finding is complicated by the fact that certain measures of QOL (e.g., the QOLIE-31) contain questions specifically asking about cognitive function and so the two constructs are not entirely distinct conceptually, at least as evaluated based on existing scale content. Finally, impairments on neuropsychological measures of memory and attention have been linked to poorer overall psychosocial functioning (Gois, et al., 2011).

Social Cognition and Functional Outcomes. Recognition of emotions in others plays an important role in daily interactions and interpersonal relationships (Lieberman, 2010) and, therefore, is potentially relevant to psychosocial outcomes. Studies do not yet exist in the epilepsy literature that draw on both neuropsychological ability (e.g., memory, which is known to be related to psychosocial functioning) and social cognitive aspects of performance. However, work in other populations suggests that these domains of functioning each make unique contributions to functional outcomes (Green & Horan, 2010). For example, research in patients with schizophrenia and bipolar disorder has linked impaired facial affect processing to poorer functional outcomes, even after accounting for neuropsychological deficits (Hoernagel, et al., 2011; Kee, Green, Mintz, & Brekke, 2003). Research on the functional implications of facial affect processing deficits in TLE is limited and has only been studied from the perspective of QOL. While two studies found no relationship between affect recognition and QOL (Bonora, et al., 2011; Broicher, et al., 2012), one study found only impaired fear recognition to be linked to the social functioning domain of QOL.

A related line of evidence linking social cognition to psychosocial functioning comes from the literature on emotional intelligence. Emotional intelligence is a relatively new concept, defined by Salovey and Mayer (1990) as “the ability to monitor one’s own and other’s feelings and emotions, to discriminate among them, and to use this information to guide one’s thinking and actions” (p. 189). Gawryluck and McGlone (2007) found self-reported emotional intelligence to be significantly correlated with psychosocial functioning as measured by the Washington Psychosocial Seizure Inventory (Dodrill, Batzer, Queisser, & Temkin, 1980). However, there was no significant relationship when self-reported emotional intelligence was examined in relation to QOL as measured by the QOLIE-31 (Walpole, Isaac, & Reynders, 2008).

Several studies have identified a relationship between performance-based emotional intelligence and functional outcomes in patient populations other than epilepsy. Specifically, Aguirre, Sergi, and Levy (2008) demonstrated that in individuals high in schizotypy, overall emotional intelligence was related to better peer relationship functioning. Similarly, lower emotional intelligence has been linked to poorer functional outcomes in patients with schizophrenia (Kee, et al., 2009). Performance based emotional intelligence has not yet been examined in epilepsy populations as a predictor of functional outcomes.

The contribution of cognitive impairments to difficulties in daily functioning is well documented in the epilepsy literature; however, little is known about the specific role that social cognitive deficits may play in functional outcomes. An understanding of the functional outcomes related to social cognition will not only provide insight into brain-behavior correlates, but also has potentially important diagnostic and treatment implications for patients with epilepsy. The goal of the present study was to further characterize social cognition in patients with TLE and provide information about the degree to which social cognition impacts everyday functioning, above and beyond the contributions of cognitive deficiencies in memory and attention that are common in TLE. Furthermore, given the presence of focal brain lesions, research in patients with TLE presents a unique opportunity to substantiate and add to the larger literature on facial affect processing.

Hypothesis 1: Patients with right anterior temporal lobectomy (ATL) are expected to perform more poorly on facial affect processing and emotional intelligence tasks than patients with left ATL.

Hypothesis 2: Poorer performance on facial affect processing and emotional intelligence tasks is expected to predict poorer psychosocial functioning outcomes in patients with ATL.

Furthermore, inferior facial affect processing and emotional intelligence performance is expected to predict poorer psychosocial outcomes above and beyond that predicted by attention, memory and executive functioning, after controlling for seizure focus.

Chapter 2

Method

Participants

Participants were drawn from individuals who had undergone anteromedial temporal lobectomy at University Hospital Medical Center, from 1994 to present. Diagnosis of unilateral (i.e., either left or right) TLE was based on the consensus of a multidisciplinary team of epileptologists using video EEG, imaging, and neuropsychological data. Participants were required to be seizure-free or experiencing well-controlled seizures in order to ensure that the epilepsy focus was correctly characterized preoperatively and the deleterious effects of ongoing seizures would not confound cognitive performance. Diagnosis and surgical status of all participants was confirmed in patient medical records. Patients with a history of serious neurological disorder other than epilepsy, serious medical condition other than epilepsy that could affect cognition, psychotic disorder, substance abuse, or intellectual disability were excluded.

Data from sixteen individuals (8 right ATL; 8 left ATL) were analyzed (see Figure 1). The majority of the participants were female (75%) and white (94%). The mean age was 43.07 years, and the mean time since anterior temporal lobectomy was 8.38 years. There were no differences in demographics between left and right ATL groups (see Table 1). All participants

were seizure free or had well-controlled seizures at the time of testing, and eight participants were taking one or more anti-epileptic medications.

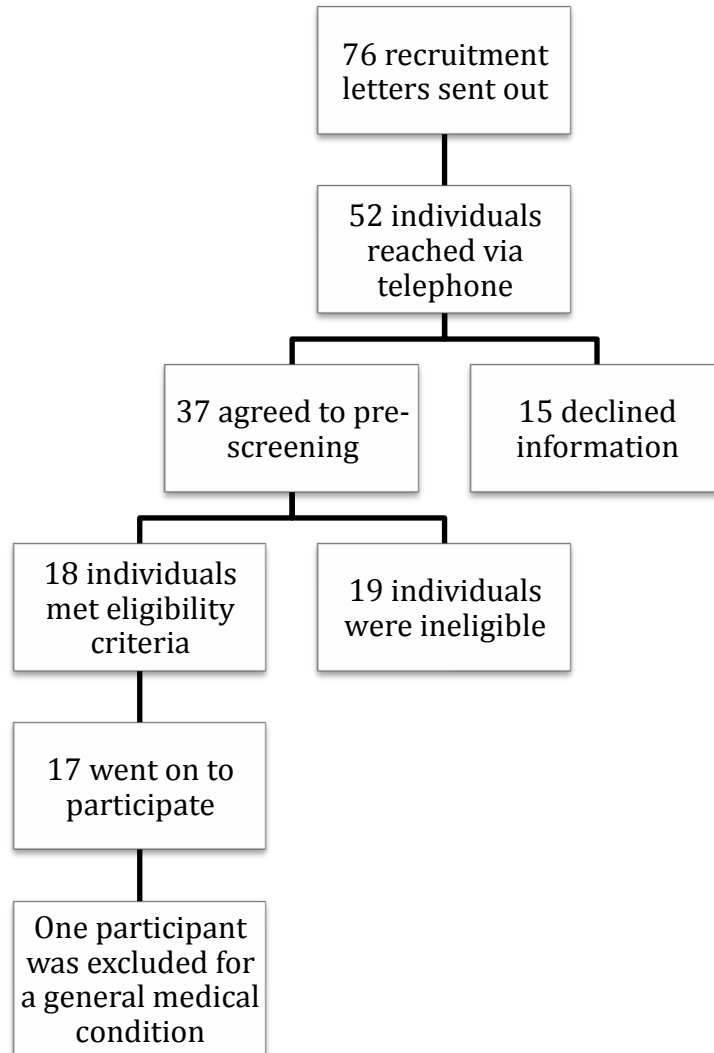


Figure 1. Flow chart depicting recruitment process.

Table 1				
Demographics: Group Means and Standard Deviations				
	Left ATL		Right ATL	
	Mean	SD	Mean	SD
Age (years)	41.63	9.05	44.50	10.57
Education (years)	13.38	1.77	13.88	2.85
Years Since ATL (years)	7.50	5.66	9.25	3.99
*Age at Epilepsy Onset	11.74	10.51	14.63	12.47
Wide Range Achievement Test – Word Reading (standard score)	90.75	5.42	100.60	14.54
Beck Depression Inventory (raw score)	11.50	10.45	10.13	14.40
<i>Notes: *Age of onset not available for one of the left ATL patients.</i>				

Procedure

The study consisted of one study session which lasted two to three hours. During the study session, the participants completed measures of memory, attention, and executive functioning (known from work in epilepsy and other populations to affect QOL and psychosocial functioning), facial affect processing, emotional intelligence, as well as self-report measures of psychosocial functioning, and QOL. Finally, the Beck Depression Inventory, Second Edition (BDI-II; Beck, Steer, & Brown, 1996) was administered to quantify depressive symptoms, which are known to be related to poorer QOL in patients with epilepsy (Jehi, et al., 2011).

Neurocognitive measures. All of the neurocognitive measures are standardized, norm-based tests that are known to be sensitive to neuropsychological deficits in patients with epilepsy. Verbal learning and memory were assessed with the California Verbal Learning Test, Second Edition (CVLT-II; Delis, Kramer, Kaplan, & Ober, 2000). Participants are read a list of words and asked to recall them across several trials. The CVLT-II also includes indices of short and long-delay free and cued recall, as well as recognition. The Brief Visuospatial Memory Test – Revised (BVMT-R; Benedict, 1997) was used to assess visual memory. During this test, participants are shown a series of figures and asked to recall and draw the figures across three

trials. The BVMT-R also includes a delayed recall trial. Working memory was measured using the Letter Number Sequencing subtest of the WAIS-IV (Wechsler, 2008). On this subtest, participants hear a series of numbers and letters and are asked to say the series back, but with the numbers first in order, and then the letters in alphabetical order. Attention was measured with the Ruff 2 & 7 (Ruff, Niemann, Allen, Farrow, & Wylie, 1997), which consists of twenty 15-second trails of search and cancellation, during which participants are to cross out twos and sevens embedded in digits or numbers. The Trail Making Test- Part A (Reitan & Wolfson, 1985) was also used to assess attention. On this task participants are asked to connect circles numbered one to 25 in ascending order as quickly as possible. Executive functioning was assessed with the Trail Making Test - Part B, a similar task on which participants are asked to alternate connecting numbers in ascending order and letters in alphabetical order. Reading level as measured by the Word Reading subtest of the Wide Range Achievement Test (WRAT-IV; Wilkinson & Robertson, 2006) was used analytically to ensure that reading level did not affect the ability to complete self-report measures. The CVLT-II, BVMT-R Ruff 2 & 7, Trail Making Test Parts A & B, and WRAT-IV produce T-scores as the unit of measure. The CVLT-II also produces z-scores; scaled scores are provided for the Letter Number Sequencing Test.

Social cognition measures. Facial affect processing was assessed with the computer- and internet-based emotion subtests from the Pennsylvania Computerized Neuropsychological Testing System (PennCNP) battery, which is a validated battery of measures that assess aspects of facial affect processing (Erwin, Gur, Gur, & Skolnick, 1992; Kohler, Bilker, Hagendoorn, Gur, & Gur, 2000; Silver, Shlomo, Turner, & Gur, 2002). On the Emotion Recognition task (ER40), the participant is presented with a total of 40 images of men and women expressing each of five emotions (happy, sad, anger, fear, and no emotion). While the photograph is on the screen, the

participant chooses (via a mouse click) the button with the label that best matched the emotion depicted in the image. On the Emotion Discrimination task (EDF40), the participant is shown 40 pairs of faces and indicates for each pair, which face is happier or sadder (depending on the item), or if the faces are equally happy/sad. On the Penn Emotional Acuity Test (PEAT40), the participant is shown 40 photographs of men and women and chooses how happy or sad the person in the picture is, based on a 7-point Likert-type rating scale ranging from “Very Sad” to “Very Happy.” For each task, the number correct and various reaction measures are collected. In order to control for any possible visual effects on the affective processing tasks, participants also completed a facial recognition task (Facial Memory from the PennCNP battery; Erwin, Gur, Gur, Skolnick, & al, 1992). The PennCNP produces raw scores for each subtest.

Emotional intelligence was assessed using the Mayer-Salovey-Caruso Emotional Intelligence Test, (MSCEIT; Mayer, Salovey, & Caruso, 2002), a computer-based test on which participants are asked to complete a variety of affective tasks. Specifically, participants are asked to identify emotions expressed on faces and in designs, generate a mood and solve problems with the mood, define the causes of different emotions and understand the progression of emotions, and finally, determine how to best include emotions in everyday situations. The MSCEIT produces T-scores for multiple subscales and an overall emotional intelligence composite.

Functional outcome measures. Psychosocial functioning was measured using the Social Adjustment Scale, Self Report (SAS-SR; Weissman, 1999), a self-report measure of satisfaction in areas of functioning as well as the frequency of certain behaviors and emotions. The Quality of Life In Epilepsy Inventory -31 (QOLIE-31; Cramer, at al., 1998), a self-report measure of feelings and satisfaction regarding specific areas of daily functioning, was used to assess quality

of life. The SAS-SR and QOLIE-31 produce T-scores for the overall composites and multiple sub-scales.

Statistical Analysis. All data distributions were examined for normality. T-tests and chi-square tests were used to check for demographic differences between groups (right vs. left ATL). Independent samples two-tailed t-tests were used to compare groups on social cognition, neurocognitive, and functional outcome measures (all $p < .10$ were considered significant). Pearson's product moment correlation coefficient was calculated to investigate the relationships between all cognitive measures and functional outcome measures. The initially planned regression models were not run due to the small sample size in this study. However, four separate regression analyses were conducted in order to confirm that the group differences on social cognition measures were not due to generalized slowing or attentional deficits. Due to the non-Gaussian distribution of the data and small sample size, non-parametric analyses were used to validate the parametric findings. In the following results, only parametric results will be reported unless non-parametric analyses generated different findings.

Chapter 3

Results

Comparison of Left and Right ATL Groups on Neuropsychological Measures

Differences between the left and right ATL groups were investigated using independent samples two-tailed t-tests. As expected, the left ATL patients performed more poorly than the right ATL patients on neuropsychological measures of verbal memory (CVLT-II long delay), $t(14) = -1.98, p = .07$, and confrontation naming (BNT) $t(14) = -2.56, p = .02$ (see Table 2). Patients with left ATL also performed more poorly than patients with right ATL on the Letter-Number Sequencing subtest of the WAIS-IV (a measure of working memory and executive

functioning), $t(14) = -1.89, p < .08$. No other significant group differences were present on the remaining neuropsychological tests ($p > .10$ for all comparisons; see Table 2).

Comparison of Left and Right ATL Groups on Social Cognition Measures

On the PennCNP social cognition battery, we obtained the counter-intuitive finding that the patients with left ATL were significantly less accurate than patients with right ATL in their ability to compare the relative intensity of emotions depicted in two faces (emotion discrimination task), $t(14) = -2.09, p = .05$ (see Table 2). In terms of reaction time on the PennCNP battery, patients with right ATL performed significantly more slowly than patients with left ATL in their ability to compare the relative intensity of emotions depicted in two faces, $t(14) = -4.15, p = .001$ and when rating the intensity of the emotional valence of facial expressions (emotional acuity task), $t(14) = -2.41, p = .03$ (see Table 2).

In order to confirm that the significant group differences on the reaction time measures of affective processing were not explicable solely on the basis of generalized slowing or attentional disturbance, four separate regression analyses were conducted to examine the presence of the group effect after removing psychomotor speed (Trail Making Test Part A) and scanning (Ruff 2&7 Speed). The effect of group on reaction time for both of the affective processing measures (emotion discrimination and emotional acuity) remained significant for all analyses, $p < .10$.

On the MSCEIT, patients with right ATL performed significantly more poorly than patients with left ATL at identifying the presence of and rating the intensity of emotions in facial expressions (faces task), $t(14) = 2.04, p = .06$ (see Table 2). There were no significant differences between groups on the facial memory or emotion recognition subtests of the PennCNP battery or on the facilitation, blends, changes, emotion management, or emotional relations tasks of the MSCEIT ($p > .10$ for all comparisons; see Table 2).

Comparison of Left and Right ATL Groups on Functional Outcome Measures

There were no significant differences between left and right ATL groups in self-reported psychosocial functioning as measured by the SAS-SR or self-reported quality of life as measured by the QOLIE-31 ($p > .10$ for all comparisons; see Table 2). Qualitative inspection of the mean scores suggested that both left and right ATL groups were within the normal to subclinical range on measures of QOL and psychosocial functioning. Although not significantly different, the right ATL patients consistently reported poorer psychosocial functioning.

Relationship Between Social Cognition Variables and Functional Outcome Measures

Pearson product-moment correlations were conducted in the full sample to investigate the relationship among the social cognition variables, quality of life as measured by the QOLIE-31, and psychosocial functioning as measured by the SAS-SR. As shown in Figures 1-3, similar correlation patterns were found between lesion groups. We obtained the counterintuitive finding that better ability to recognize neutral facial expressions on the emotion recognition task of the PennCNP was significantly correlated with poorer self-reported family unit functioning as measured by the SAS-SR, $r(14) = -.51, p < .05$. Poorer ability to correctly judge the relative intensity of emotions displayed across two faces (emotion discrimination) on the PennCNP was significantly correlated with lower self-reported cognitive functioning on the QOLIE-31, $r(14) = .54, p < .05$ and with poorer overall quality of life as measured by the QOLIE-31, $r(14) = .50, p < .05$ (see Figure 1). Additionally, less accurate performance on the emotion discrimination task was significantly related to poorer social and leisure functioning, $r(14) = -.49, p = .05$, and to poorer overall psychosocial functioning, $r(14) = -.49, p = .05$, as measured by the SAS-SR, (these correlations were not significant, $p < .10$, when tested non-parametrically; see Figure 1).

Poorer performance on the emotion management task of the MSCEIT, which measures one's ability to incorporate his or her own emotions into decision making, was significantly related to lower self-reported functioning on both the QOLIE-31 and SAS-SR. Specifically, less accurate performance on the emotion management task was significantly correlated with poorer self-reported emotional well-being ($r(14) = .51, p < .05$) and social functioning ($r(14) = .54, p < .05$) as measured by the QOLIE-31 (these correlations were not significant, $p < .10$, when tested non-parametrically; see Figure 2). Poorer performance on the emotion management task of the MSCEIT also predicted poorer self-reported social and leisure functioning, $r(14) = -.53, p < .05$, as measured by the SAS-SR (see Figure 2). There were no other significant relationships between social cognition variables and functional outcome measures ($p > .05$ for all comparisons). We ran 162 correlations, 7 were significant, and 1 significant correlation went the wrong way.

Relationship Between Neuropsychological Variables and Functional Outcome Measures

The relationship between neuropsychological variables and functional outcome measures in the full sample was also investigated using Pearson correlations. Poor performance on the Boston Naming Test was significantly correlated with lower self-reported cognitive functioning on the QOLIE-31, $r(14) = .65, p < .05$, and with lower overall quality of life, $r(14) = .48, p = .05$. However, further investigation of the data revealed three outliers, all in the right ATL group and all with T-scores greater than 60 on the Boston Naming Test. When these patients were removed, the correlations between the BNT and the QOLIE were small to medium, $r = .28$ to $.31$, and non-significant, $p > .05$. There were no other significant relationships between neuropsychological measures and functional outcome measures ($p > .05$ for all comparisons).

Relationship Among Depression and Social Cognition and Functional Outcome Measures

As expected, higher self-reported depression as measured by the Beck Depression Inventory was significantly correlated with lower self-reported quality of life ($r(14) = -.85, p < .05$) and with poorer psychosocial functioning ($r(14) = -.77, p < .05$). Self-reported depression was not correlated with any of the social cognition variables, all $p > .05$.

Relationships Between Quality of Life and Psychosocial Functioning

The QOLIE-31 and SAS-SR were strongly correlated on multiple domains (see Table 3), including the overall QOLIE-31 and overall SAS-SR scores, $r(14) = -.89, p < .05$ (see Figure 3).

	Left ATL		Right ATL	
	Mean	SD	Mean	SD
Neuropsychological Measures				
California Verbal Learning Test-II Learning Trials (T-score)	38.75	11.59	43.50	13.86
*California Verbal Learning Test-II Long Delay (Z-score)	-2.06	1.24	-0.75	1.41
Brief Visual Memory Test-R Learning Trials (T-score)	35.50	12.24	43.00	14.86
Brief Visual Memory Test-R Delay (T-score)	40.88	16.57	43.13	14.82
Trail Making Test - Part A (T-score)	45.50	7.11	42.75	10.05
Trail Making Test - Part B (T-score)	41.63	10.18	49.50	13.42
Ruff 2 & 7 Speed (T-score)	47.38	7.71	45.00	12.39
Ruff 2 & 7 Accuracy (T-score)	44.88	9.13	44.50	11.64
*Letter-Number Sequencing (WAIS-IV; Scaled Score)	8.38	2.00	11.00	3.38
*Boston Naming Test (T-score)	31.63	6.41	46.75	15.40
Social Cognition Measures – PennCNP Battery				
Facial Memory Test (raw score)	30.75	2.71	28.13	3.91
Emotion Recognition (raw score)	30.00	7.11	32.50	2.78
Emotion Recognition Reaction Time (ms)	2255.9	472.0	2624.1	561.7
Emotion Recognition Anger (raw score)	4.63	1.60	5.25	1.83
Emotion Recognition Fear (raw score)	6.13	1.25	6.00	1.31
Emotion Recognition Happy (raw score)	7.75	.46	7.88	.35
Emotion Recognition Neutral (raw score)	6.38	2.83	6.50	1.77
Emotion Recognition Sad (raw score)	6.25	1.49	6.89	1.00
*Emotion Discrimination (raw score)	20.13	8.58	26.88	3.09
*Emotion Discrimination Reaction Time (ms)	3385.8	821.0	5197.2	922.9
Penn Emotional Acuity Test (raw score)	26.13	2.47	23.75	5.70
*Penn Emotional Acuity Test Reaction Time (ms)	1951.2	352.1	2414.1	413.4
Social Cognition Measures - MSCEIT				
*Faces Task (Std. Score)	121.4	24.23	98.61	20.23

Changes Task (Std. Score)	86.70	15.05	92.61	14.88
Facilitation Task (Std. Score)	111.3	18.56	108.3	15.67
Emotion Management (Std. Score)	95.58	14.01	92.17	16.94
Blends Task (Std. Score)	81.91	9.12	86.97	15.48
Emotional Relations (Std. Score)	93.39	10.30	91.31	12.69
Total Emotional Intelligence (Std. Score)	92.03	16.89	88.10	18.24
Psychosocial Functioning				
Social Adjustment Scale – Work Role	54.37	17.03	63.50	15.26
Social Adjustment Scale – Social & Leisure	56.00	19.22	59.38	12.66
Social Adjustment Scale – Extended Family	60.38	23.16	63.75	25.39
Social Adjustment Scale – Family Unit	60.25	22.89	63.38	24.04
Social Adjustment Scale – Overall	59.63	24.55	63.75	19.14
Quality of Life				
Quality of Life in Epilepsy-31 – Emotional Well Being	51.25	10.74	48.75	15.15
Quality of Life in Epilepsy-31 – Cognitive Functioning	45.50	10.13	55.00	13.52
Quality of Life in Epilepsy-31 – Social Functioning	53.00	12.93	50.38	15.01
Quality of Life in Epilepsy-31 – Overall	50.38	14.57	53.50	15.68
<i>Notes: *Significant difference between groups, $p < .10$</i>				

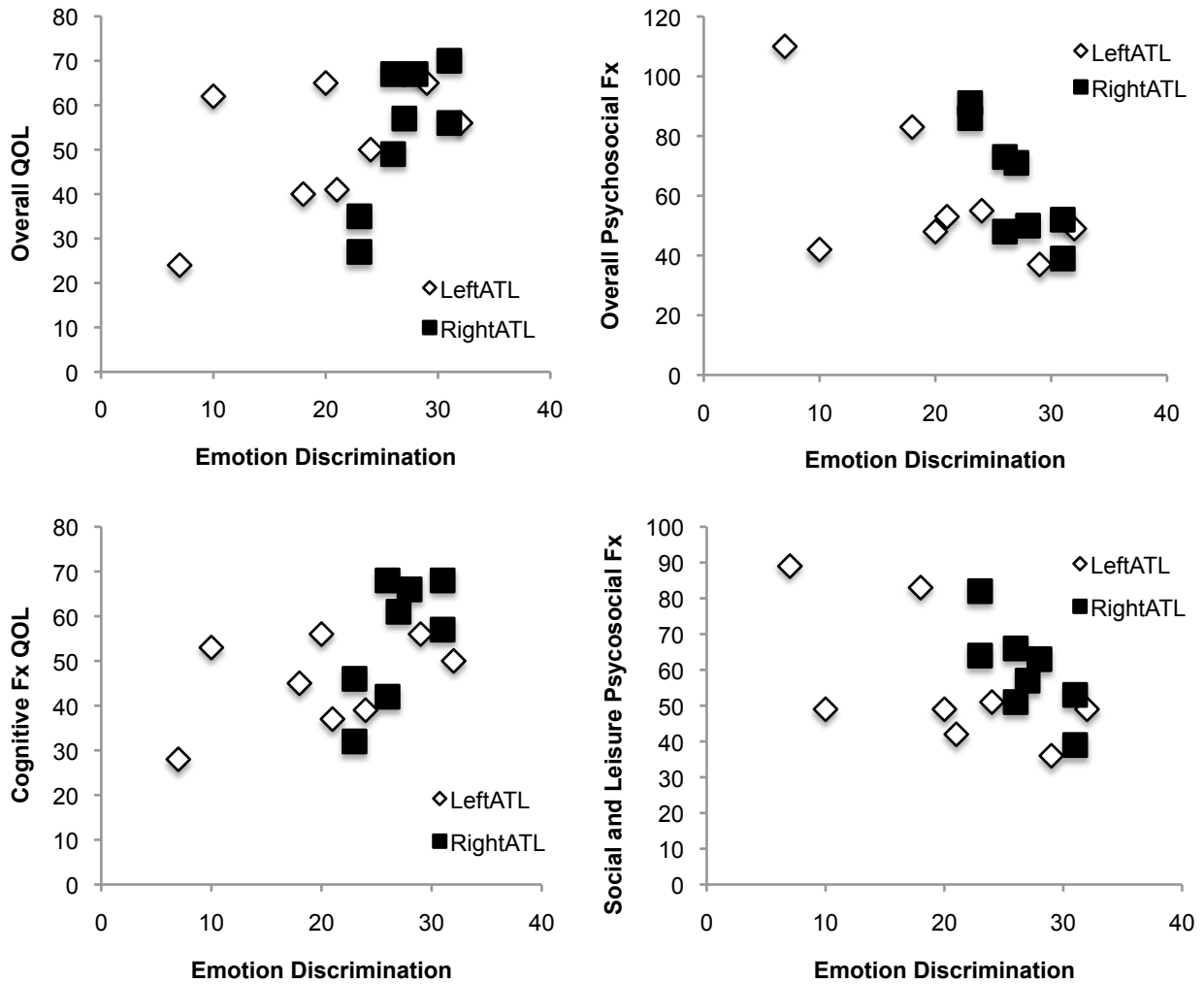


Figure 2. Relationships between the Emotion Discrimination task of the PennCNP and functional outcome measures. Vertical axes represent T-scores; horizontal axes represent raw scores.

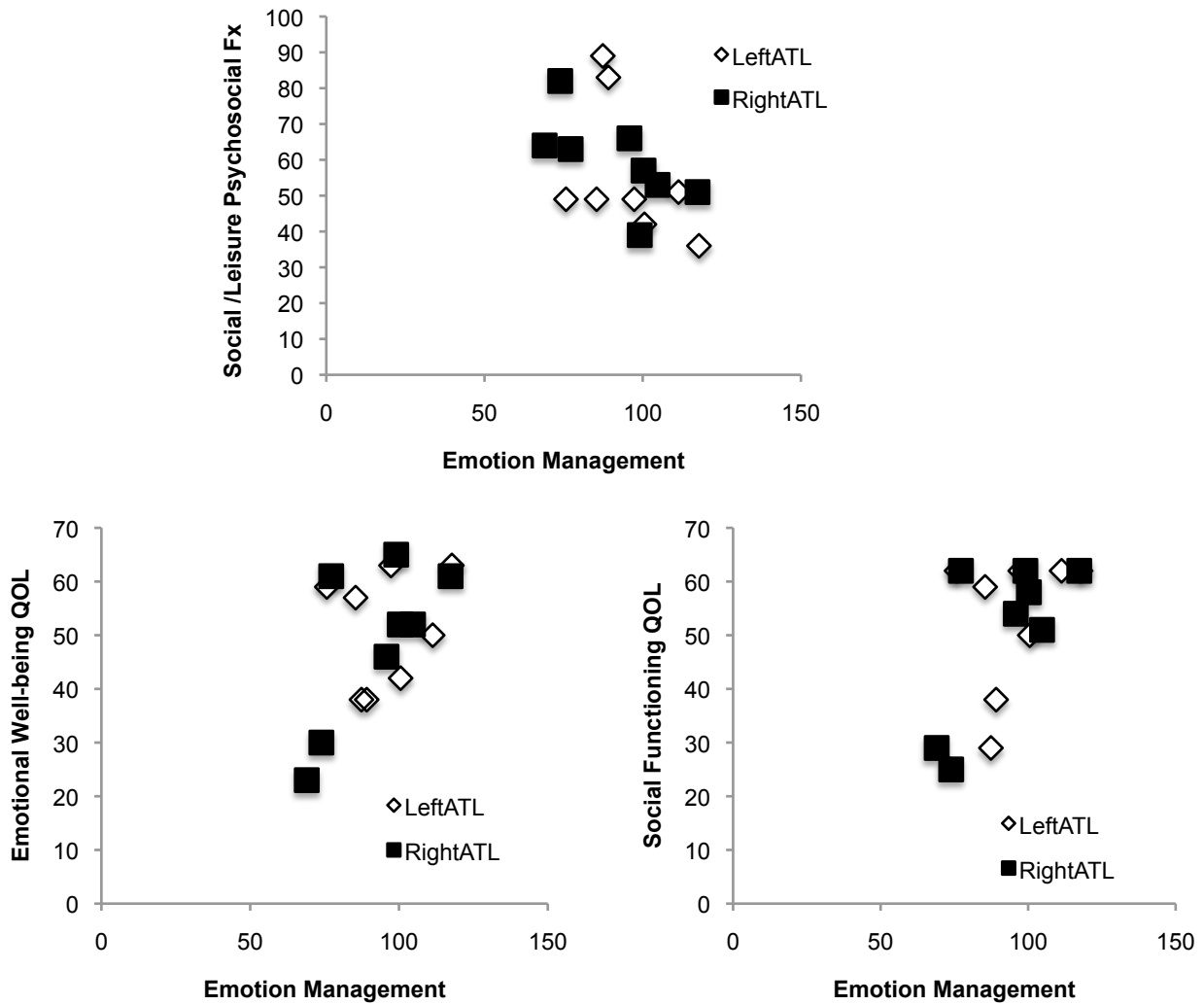


Figure 3. Relationships between the Emotion Management task of the MSCEIT and functional outcomes measures. Vertical axes represent T-scores; horizontal axes represent standard scores.

Table 3				
Pearson Correlation Between Quality of Life and Psychosocial Functioning				
	Emotional Well-Being	Cognitive Functioning	Social Functioning	Overall QOL
Work Role	-0.77*	-0.56	-0.83*	-0.78*
Social and Leisure	-0.69*	-0.48	-0.79*	-0.71*
Extended Family	-0.79*	-0.71*	-0.74*	-0.84*
Family Unit	-0.85*	-0.68*	-0.88*	-0.89*
Overall	-0.85*	-0.70*	-0.88*	-0.89*

Note: *significant at the $p < 0.05$ level

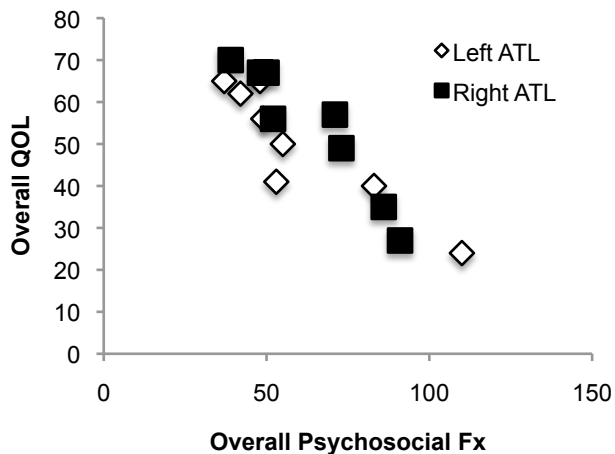


Figure 4. Relationship between overall QOL as measured by the QOLIE-31 and overall psychosocial functioning as measured by the SAS-SR. Vertical and horizontal axes represent T-scores.

Chapter 4

Discussion

The current study investigated the social cognitive domains of facial affect processing and emotional intelligence in patients who had undergone anterior temporal lobectomy (ATL) for temporal lobe epilepsy. Within the epilepsy literature, social cognition primarily has been studied from the perspective of affect labeling, meaning that tasks have required participants to indicate the name of the facial affect being expressed. The present study examined a breadth of social cognitive skills, which have not previously been investigated in this population, including emotion intensity processing and emotional problem solving tasks.

A novel finding of the present study was that the right ATL patients were at a disadvantage compared to the left ATL patients in their reaction time on two tasks that involved processing the intensity of facial emotions. The patients with right ATL performed more slowly than those with left ATL while judging the relative intensity of emotions and while rating the

intensity of the emotional valence in facial expressions. In contrast, the right ATL group was comparable to the left ATL group in *accuracy*, suggesting that the patients with right ATL sacrificed speed for accuracy on these tasks. Consistent with this finding, previous research has shown reaction time deficits in patients with TLE, despite normal accuracy performance, on a sustained attention task (Fleck, Shear, & Strakowski, 2002). Although there were no processing speed or attentional differences between left and right ATL groups in the present sample, in order to be conservative, the effect of group on reaction time was confirmed after taking processing speed and attentional abilities into account. The effect of group on reaction time remained significant, suggesting that the observed deficit in reaction time is at least partially independent of these factors.

Lines of evidence from other populations have shown a similar speed-accuracy trade off. Such deficits of reaction time in the context of unimpaired accuracy have been found in patients with disturbances of affect (e.g., anxiety, mania) and are referred to as deficits in processing efficiency (Eysenck & Calvo, 1992; Fleck, Shear, & Strawkowski, 2005). Processing efficiency is defined by performance effectiveness in relation to measures of mental effort such as reaction time. A related finding is that patients with bipolar disorder demonstrate reaction time deficits when matching and labeling facial affect (Getz, Shear, & Strakowski, 2002). Reaction time is often overlooked in measures of performance accuracy; however, in daily interactions there is a very limited amount of time to process the facial expressions of others. Accurate recognition of emotional expressions is important in daily social interactions (Lieberman, 2010); if one cannot be fast and accurate in the processing of emotions in others, he or she may miss important social cues, which may lead to interpersonal difficulties.

In addition to the reaction time findings above, the hypothesis that patients with right

ATL would perform more poorly than patients with left ATL on measures of facial affect recognition was partially supported by accuracy data. The right ATL group performed more poorly than the left ATL group in their ability to recognize and rate the intensity of five different emotions depicted in a facial expression (Faces subtest of the MSCEIT). Given the emotion recognition and intensity discrimination requirements on this task, it is difficult to determine whether the group difference primarily reflects the ability to recognize the emotion depicted in the facial expression or to discriminate the intensity of the emotion depicted. In contrast, there was no significant difference between groups on a task that required labeling of pictured affect (Emotion Recognition task of the PennCNP). This latter finding, however, is inconsistent with a previous report that patients with right ATL perform more poorly than patients with left ATL on emotion labeling tasks (Aldophs, Tranel, & Damasio, 2001).

There are multiple potential reasons for these discrepant findings. Mean age of epilepsy onset in the current sample was 13.51 years; however, research has consistently shown that early age at epilepsy onset (i.e., < 6 years) is related to significantly more impairment in affect labeling ability (Benuzzi, et al., 2004; McClelland, et al., 2006; Meletti, et al., 2003). The lack of lateralizing effects on the labeling task may be related in part to differences between the current sample of patients and those in previous research that were found to be most at risk for deficits in facial affect labeling. More in line with our sample, Bonora and colleagues (2011) investigated facial affect labeling in a sample with later age of onset (mean = 20.27 years), and while they found that mesial TLE patients as a group performed more poorly than healthy controls, they did not find any difference between left and right mesial TLE groups. Another limitation of the current study was the lack of data regarding the extent of surgical resection and presence of mesial temporal sclerosis on pathology, the latter of which is known to be a predictor of impaired

facial affect labeling (Benuzzi, et al., 2004; McClelland, et al., 2006; Meletti, et al., 2003).

The social cognitive and emotional intelligence findings in the current study appear in the context of the neuropsychological deficits that are well-documented in this population.

Consistent with previous literature, patients with left ATL performed more poorly than those with right ATL on measures of verbal memory (CVLT-II long delay) and confrontation naming (BNT; Loring, 1997; Moore & Baker, 2002). Patients with left ATL in the present study also performed more poorly on a verbal working memory task (Letter-Number Sequencing). Deficits in verbal working memory have previously been found among patients with mesial TLE, although no effect of lateralization was reported (Campo, et al., 2009; Zamarian, et al., 2011). There were no general cognitive deficits that were worse in the right than the left ATL group. In fact, the general cognitive deficits went in the other direction, and therefore are unlikely to have contributed to the disadvantage of the right ATL group on the social cognitive measures. In addition, there were no demographic or IQ differences between groups that would explain the affective findings.

In terms of accuracy on the emotion discrimination task of the PennCNP, we obtained the counter-intuitive result that patients with left ATL performed more poorly than those with right ATL. One possible explanation may be related to the use of facial expressions displaying only happiness and sadness. The affective processing difficulties among patients with epilepsy have been linked to damage to the right amygdala (Benuzzi, et al., 2004; McClelland, et al., 2006; Meletti, et al., 2003), and while the amygdala is thought to be involved in the processing a range of emotions, it is most strongly linked to the processing of fear and anger (e.g. Adolphs, Tranel, & Damasio, 2001; Adolphs, Baron-Cohen, & Tranel, 2002; Liberman, 2010; McClelland, et al., 2006; Meletti, et al., 2003; Phillips, Drevets, Rauch, & Lane, 2003). We are not aware of other

studies in the epilepsy literature involving this aspect of facial affect processing; however, patients with schizophrenia have been shown to perform more poorly than healthy controls on the aforementioned task. In particular, patients with flat affect perform more poorly than other patients with schizophrenia and more poorly than healthy controls (Gur , et al., 2006).

Additionally, an effect of the intensity of emotion in facial expressions has been shown in patients with schizophrenia, in that they are less accurate in recognizing both mild intensity and extreme intensity emotional expressions than in recognizing emotional expressions of moderate intensity (Kohler, et al., 2003). Given the reaction time and accuracy findings of the current study, further investigation of the discrimination of the intensity of emotions in facial expressions and the effects of the intensity of emotions on emotion recognition in patients with temporal lobe epilepsy is indicated. Specifically, there is a need for data addressing whether the intensity of an emotion in a facial expression impacts an individual's ability to label that emotion and whether certain patients are at higher risk for deficits in discriminating the intensity of emotions.

To our knowledge, the present study is the first to demonstrate a relationship between affective processing and functional outcomes in patients with epilepsy. In the entire sample together, poorer ability to discriminate the relative intensity of an emotion between two facial expressions was related to lower self-reported QOL and psychosocial functioning. Similarly, more errors in rating the effectiveness of alternative actions in regulating emotions (Emotion Management task of the MSCEIT) was related to poorer QOL and psychosocial functioning. These results are consistent with research in patients with schizophrenia and bipolar disorder that have found the social cognitive domains of affective processing and emotional intelligence to be related to outcomes in psychosocial functioning (Aguirre, Sergi, & Levy, 2008; Hoertnagl, et al.,

2011; Kee, Green, Mintz, & Brekke, 2003; Kee, et al., 2009).

The finding that the QOLIE-31 and SAS-SR were strongly correlated (r ranging from .48 to .89) is inconsistent with the prior existing report in patients with TLE that no subtests were significantly correlated except the cognitive functioning domain of the QOLIE-31 and the overall score on the SAS-SR (Gois, et al., 2011). The study by Gois and colleagues was in patients who had not undergone surgery for TLE. Given the number of seizure-related questions on the QOLIE-31, the impact of ongoing seizures in the Gois sample may have impacted self-report on the QOLIE-31 more so than in our sample. It is possible that the relationship between QOL and psychosocial functioning differs between those who are still experiencing seizures and those who are seizure free. A major premise of this study was that measures of QOL do not capture the breadth of an individual's psychosocial functioning or ability to interact with others and function effectively in society. Although the sample size in the current study is too small to draw definitive conclusions, the magnitude of the observed correlations support the notion that QOL and psychosocial functioning are closely related constructs.

The primary limitation of the current study was the small sample size, which resulted in a reduction in statistical power, precluded multivariate modeling, and limited generalizability. In addition, the rigorous exclusion criteria (i.e., the exclusion of those with neurological disorders other than epilepsy or other medical condition that could affect cognition), resulted in a sample that omitted several common etiological risk factors for epilepsy, such as brain tumors and traumatic brain injury. Another limitation was the lack of a healthy control group, without which we cannot make conclusions regarding whether our sample performed below normal expectations on study tasks. Finally, one must consider the possible effects of anti-epileptic medication on cognitive performance. It is not probable that medication effects fully explain the

findings, as the significant group effects remained after controlling statistically for those areas of cognition most likely to be impacted by anti-epileptic medications, but it is nevertheless possible that a portion of the measured results were due to medications.

We documented a disadvantage for right ATL patients in multiple areas of social cognition, with effects on both accuracy and speed. In addition, poorer in social cognitive functioning was related to QOL and psychosocial functioning outcomes; however, the same measures that differentiated left and right ATL groups did not always predict functional outcomes. It is important to note is that these relationships were found in patients who are seizure free, and on average, many years post-operative, highlighting the need to understand predictors of psychosocial functioning that extend beyond seizure control. The clinical implications are potentially substantial. With growing evidence that deficits in social cognition contribute to impaired psychosocial functioning, at least partially independent of other disease related and neuropsychological variables, an important future direction is the investigation of interventions to improve social cognition. Similar research in schizophrenia has lead to empirically supported interventions focusing on social cognition remediation and social skills training, with the goal of improving psychosocial functioning in these patients (for review see Green & Horan, 2010).

The findings also have potential implications for diagnostic neuropsychological evaluations in patients with temporal lobe epilepsy. Generally speaking, neuropsychological instruments are more sensitive to left TLE than right TLE (Loring, 1997; Raspall, et al., 2004; Wisniewski, Wendling, Manning, & Steinhoff, 2012). Peters and colleagues (2011) found that ictal dysprosody is associated with right temporal lobe seizures, supporting the notion that affective processing abilities lateralize to the right temporal lobe. With growing evidence for

impaired facial affect processing in patients with right temporal lobe epilepsy, such measures may prove useful in neuropsychological evaluations, which are often conducted with the goal of providing information regarding lesion lateralization and localization.

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