- Investigation of autistic characteristics in epilepsy
- Two conditions for self-assessment, with/without self-perceived seizure activity
- Adults with epilepsy self-rated more reciprocal social interaction deficits
- Reciprocal social deficits worsened during self-perceived mild seizure activity

Autistic Characteristics in Adults with Epilepsy and Self-Perceived Seizure Activity

SallyAnn Wakeford*[a], Neal Hinvest[b], Howard Ring[c], Mark Brosnan[b]

[a] Department of Health Psychology, Building 44, Highfield Campus, University of Southampton, UK. SO17 1BJ. Tel: +44 (0)7961 053 633. email: s.wakeford@bath.edu. [b] Department of Psychology, University of Bath, UK. email: n.hinvest@bath.ac.uk. [c] Department of Psychiatry, University of Cambridge, Cambridge, UK. [4] Department of Psychology, University of Bath, UK. email: m.j.brosnan@bath.ac.uk

* Corresponding author.
E-mail address: s.wakeford@bath.edu

Abstract

The prevalence of autism spectrum disorders in epilepsy is approximately 15%-47%, with previous research by Wakeford and colleagues reporting higher autistic traits in adults with epilepsy. The aim of this study was to investigate autistic characteristics and their relationship to having seizures by employing two behaviour assessments in two samples: adults with epilepsy and controls. *Method:* The study employed the Social Responsiveness Scale shortened, SRS-S (epilepsy *n*=76, control *n*=19) and the brief Repetitive Behavior Scale-Revised, RBS-R (epilepsy *n*=47, control *n*=21). This study employed a unique method to quantify the extent to which autistic characteristics are related to perceived mild seizure activity. Adults with epilepsy were instructed to rate their usual behaviour on each assessment, and at the same time rate again for their behaviour when they perceived they were having mild seizure activity. *Results*: Significantly higher SRS-S scores were related to having a diagnosis of epilepsy, and were perceived by adults with epilepsy to increase during mild seizure activity. These scores positively correlated with anti-epileptic drug control. No difference was found for RBS-R scores in adults with epilepsy compared to controls. *Conclusion:* Together, these results suggest that adults with epilepsy have higher autistic characteristics measured by the social responsiveness scale, while sameness behaviours remains unimpaired. The autistic characteristics measured by the social responsiveness scale were reported by adults with epilepsy to be more severe during their mild seizure activity.

1. Introduction

The prevalence rates for autism spectrum disorders (ASD) in epilepsy range from 15%-47% [1-3]. ASDs are a severe developmental disorder, defined as a markedly abnormal or impaired development in social interaction and communication, and markedly restricted repetitive repertoire of activity and interests [4]. There is not one single diagnosis of autism, but a spectrum of disorders commonly termed as autistic spectrum disorders [ASD] [5]. Notably, social interaction impairment is gross and sustained. High heritability of autism has been shown consistently largely due to high concordance in monozygotic twins and low concordance in dizygous twins. Although epilepsy is a neurobiological disorder that is not specifically characterised by heritability, research has found a significantly higher rate of autistic traits in adults with epilepsy than adults without epilepsy [6]. Little is known about the relationship of epilepsy to the core features of ASD [7]. To investigate autistic characteristics in epilepsy, this study examined the core autistic characteristics of restricted, repetitive and stereotyped patterns of behaviour and social reciprocal interaction using two shortened assessment scales.

Since Kanner's original identification of the characteristics of ASD, social impairments have been a central defining feature of ASD [8]. The high co-morbidity and higher level of autistic traits in epilepsy indicate a need to specifically evaluate these characteristics and the factors that influence their presence. Studies of social cognition in epilepsy have been neglected. Research investigating social cognition have established that epilepsy can affect brain structures important for socio-emotional processing, as well as neural networks mediating social cognition that are essential for social behaviour [9]. This suggests that the pathogenesis of epilepsy may disrupt social cognitive abilities, although the extent to which social cognitive functioning may be influenced by neurobiological, psychosocial, and psychologic factors is still unknown and poorly understood [10]. Notably though, social functioning in children may be related to seizure frequency [11, 12]. Factors implicated in social dysfunction include chronic epilepsy [13], and severe and frequent seizures [14, 15]. Consistent with these findings, this study seeks to investigate whether seizure-related factors are implicated in these specific autistic characteristics. A review of AED use in autism and their association to affective disorders found that 85% of the literature reported that affective AEDs improved the core autistic symptoms of socialisation and communication; notably though this evidence was based on case reports and not controlled clinical trials [16]. This study assessed AED effectiveness regardless of AED type, to undertake an initial exploration whether AEDs may be related to autistic characteristic of socialisation in epilepsy.

This study employed a shortened version of the Social Responsiveness Scale (SRS) to assess ASD characteristics including reciprocal social behaviour [17, 18]. Reciprocal social behaviour is the ability to identify and interpret the emotional cues of others, and respond and engage in social interactions appropriately. The shortened form assesses 3 subscales from the SRS: social impairment, language impairment and stereotyped/repetitive behaviour [19]. SRS scores of individuals with ASD are consistently higher than those of individuals with other psychological or developmental disorders such as ADHD, anxiety, and other non-ASD social impairments [20, 21]. Researchers have demonstrated a significant positive relationship between SRS-S and Autism-Spectrum Quotient (AQ) scores [22]. Consistent with previous research showing higher AQ scores in adults with epilepsy than controls, this study aimed to investigate ASD characteristics and their relationship to seizures by employing the SRS-S [6].

In addition, restricted, repetitive and stereotyped patterns of behaviour (RRBs) were investigated to look at the relationship of non-social ASD characteristics and their relationship to seizures. Repetitive behaviours are a pervasive feature of ASD, and severity of ASD has been correlated with 'sameness' behaviours [23, 24]. Despite the high co-morbidity of ASD in epilepsy there has been little research of RRBs in epilepsy, and no prior evidence for elevated restricted repetitive behaviours in people with epilepsy was found in our literature review. This study aimed to investigate these characteristics by employing an index of 'sameness' behaviours.

To examine the relationship of seizure activity and ASD characteristics, this study required adults with epilepsy to self-assess in two conditions: with and without self-perceived mild seizure activity. This method was suitable for participants who believed that they could rate their behaviour during a time when they were having mild seizure. In order to elicit this information, this study aimed to invite participants to complete the behavioural rating scales twice by reflecting on behaviours with and without a mild seizure and then self-rating for both conditions, for each statement response. This differs to current self-rated assessments which presently invite participants to provide only one response and does not capture any change in behaviour. Hoppe and colleagues state that epileptology depends on the assumption that patient seizure data provide reliable and valid information, and whilst two studies have confirmed the reliability of patient seizure memory, patients tend to under report the frequency of their epileptic activity [25]. A number of studies have used self-rated and interview-based measures that rely on accurate reporting by the subjects about their epilepsy and their emotional states, although to-date no instruments have yet been developed specifically for the assessment of behavioural disturbances in epilepsy [26]. For some individuals with epilepsy, daily mild seizure activity is not uncommon. Therefore identifying behaviour associated with self-perceived mild seizure activity is essential as these changes may impact on daily life.

In this research, we aimed to assess ASD characteristics in adults with and without epilepsy, and to trial a unique method of self-assessment for behaviours with and without seizure activity to

determine whether there is a relationship between ASD behavioural characteristics and mild seizures. We hypothesized that across the participants with epilepsy, there would be an increase of ASD characteristics with higher scores on the SRS-S and higher scores on the RBS-R (shortened), and this would be more pronounced during self-perceived mild seizure activity. Consistent with some previous anecdotal evidence that AEDs may reduce socialization in those with ASD and that chronic epilepsy may be related to an increase of social difficulties, we hypothesized that both AED effectiveness and chronic epilepsy would be associated with autistic characteristics measured by the shortened social responsiveness scale.

2. Method

2.1 Study design

Two groups of adults were recruited for these short assessments: a control group without epilepsy, and a heterogeneous group with epilepsy. Experiments 1 & 2 employed shortened assessment tools, chosen to eliminate the high drop-out rate of 52% adults with epilepsy demonstrated on our previous study [6]. In this study, adults with epilepsy were introduced to a new method for assessment and needed to undertake some reflection and consider each statement carefully, judging one condition 'without self-perceived mild seizure activity' against another 'with self-perceived mild seizure activity' (see section 2.2.1.2). Therefore, the shorter assessments seemed appropriate. Experiments 1 and 2 investigated the presence of ASD, Experiment 1 employed the Social Responsiveness Scale-Shortened (SRS-S) and Experiment 2 employed the RBS-R (shortened).

Experiments 1 and 2 were two separate studies with two separate participant samples, although participants in Experiment 1 were invited to take part in Experiment 2 (see section 2.1.2.1.1 for details of sample overlap).

2.1.1 Experiment 1

2.1.1.1. Participants

2.1.1.1.1. *Method of recruitment.* This study mainly used an opportunity sampling method and recruited participants from adverts on epilepsy charity websites and through University psychology departments in addition to recruitment of existing participants. The advert invited participants who believed that they could remember their mild seizure activity to take part in a study about their seizures. It included 26 participants (Epilepsy *n*=17) who were recruited from our previous study [6].

2.1.1.1.2. *Exclusion criteria.* All participants were excluded if they had reported having a diagnosis of an ASD. Only adults ($\geq$ 18 years) participated. Epilepsy group: no participant had an autism-

epilepsy syndrome, e.g., Dravet's Syndrome. Participants self-reported their epilepsy type. Adults with a diagnosis of epilepsy self-reported whether their epilepsy was active defined by the study criteria for 'active epilepsy'. Adults with epilepsy who did not meet this criteria were excluded. Active epilepsy has previously been defined as ranging from experiencing epilepsy within the last 6 months, to the ILAE criteria of one or more epileptic seizures in the previous 5-year period (ILAE, 1993), while surgical outcomes are characterised using the Engel Class [27]. In our study, we defined active epilepsy as one or more seizure in the last 12 months (excluding seizure aura), or one or more non-aura seizure in the last 24 months and one or more seizure aura in the last 12 months, with or without AED discontinuation.

2.1.1.1.3. Participant samples. The sample comprised *n*=95: Control Group *n*=19, Epilepsy *n*=76 (see Tables 1 and 2).

Table 1
Demographics.

	Controls (*n*=19) Female *n*=15, Male *n*=4			Epilepsy (*n*=76) Female *n*=54, Male *n*=20 Unknown *n*=2		
	Mean	*SD*	*Range*	*Mean*	*SD*	*Range*
Age	42.5	(13.2)	22.6-66.4	36.0	(11.5)	18.2-60.9

Table 2
Classification of epilepsy type.

Classification of epilepsy	*n*	%
Primary Type:		
Temporal Lobe Epilepsy	18	23.7
Other Focal Epilepsy	32	42.0
Absence Epilepsy	2	2.7
Myoclonic Epilepsy	2	2.7
Idiopathic Generalised Epilepsy	14	18.3
Unknown	8	10.5
Total	**76**	**100.0**

Epilepsy classification was self-reported by participants who had epilepsy,
primary epilepsy type at diagnosis was used for classification of epilepsy type.

2.1.1.1.4. As chronic epilepsy may be a factor for social dysfunction, it would be worthwhile investigating 'years of epilepsy' as a potential factor for severity. Therefore, participants were asked to report the total number of years of having epilepsy from onset of epilepsy (date of diagnosis). This was reported as: Years of epilepsy: n=51, [mean=19.6 years, SD=12.6, range: 1-52 years], or unknown, n=25.

2.1.1.1.5. Anti-Epileptic Drugs. Participants were asked to self-rate the effectiveness of AEDs for controlling their epilepsy, using a 5-point Likert Scale: 1=Totally uncontrolled, 2=Poorly controlled, 3=Partially controlled, 4=Reasonably well controlled, 5=Well controlled.

2.1.1.1.6. Missing data. The exclusion threshold was set at 3 omitted responses. Missing data values were replaced by the median value for each item. Several participants requested another set of material but returned both sets. In such instances, the most recent responses were included for analysis, [*n*=3].

2.1.2 Experiment 2

2.1.2.1. Participants

2.1.2.1.1. Method of recruitment. This study mainly used an opportunity sampling method and recruited participants from adverts on epilepsy charity websites and through University psychology departments in addition to recruitment of existing participants. It included 68 participants (Epilepsy n=40; Controls n=17) who were recruited for our previous study examining autistic traits employing the AQ. Sample overlap: the number of participants with epilepsy who completed both Experiments 1 and 2: for 'without' condition: n=21, and 'with' condition: n=15.

2.1.2.1.2. Exclusion criteria. Exclusion criteria were the same as those employed in experiment 1.

2.1.2.1.3. Participant samples. The sample comprised *n*=68: Control Group *n*=21, Epilepsy *n*=47 (see Tables 3 and 4).

2.1.2.1.4. Anti-Epileptic Drugs. Participants were asked to self-rate the effectiveness of AEDs for controlling their epilepsy, using a 5-point Likert Scale employed for Experiment 1.

2.1.2.1.5. Missing data. Criteria were the same as those employed in Experiment 1.

Table 3
Demographics.

	Controls (*n*=21) Female *n*= 18, Male *n*=3			Epilepsy (*n*=47) Female n=36; Male n=11		
	Mean	*SD*	*Range*	*Mean*	*SD*	*Range*
Age	41.2	(13.4)	23.0-67.0	38.4	(11.5)	22.0-62.0

Table 4
Classification of epilepsy type.

Primary Type of epilepsy	***n***	**%**
Temporal Lobe Epilepsy	21	44.7
Other Focal Epilepsy	6	12.8
Myoclonic Epilepsy	1	2.1
Idiopathic Generalised Epilepsy	18	38.3
Unknown	1	2.1
Total	**47**	**100.0**

Epilepsy classification was self-reported by participants with epilepsy, primary epilepsy type at diagnosis was used for classification of epilepsy type.

2.2. Assessment of features of ASDs

2.2.1. Experiment 1

The SRS-S was provided in paper format and digital format. Participants were provided with the following: i) personal details form, ii) SRS-S and instructions, iii) a feedback form.

2.2.1.1. *The Social Responsiveness Scale-Shortened.*

The SRS and its shortened version the SRS-S were developed as a quantitative measure of autistic traits. The full version SRS is a validated quantitative measure of severity of social impairment and scores are generally unrelated to IQ [17]. It comprises of 65 items related to 5 domains: social awareness, social information processing, capacity for reciprocal social communication, social anxiety/avoidance, and autistic preoccupations and mannerisms. The shortened measure is a brief, self-report assessment and consists of 11 self-report SRS items, covering a range of ASD traits with the highest factor loadings [22, 28]. These 11 items cover the 3 core areas ranging from social difficulties, communication problems, and other atypical patterns of behavior including restricted areas of interest. The SRS-S has been shown to be well validated against the full SRS [22]; it has been previously utilised in research studies to identify ASD characteristics [19, 28, 29]. Participants self-

rated their responses on a 4-point Likert scale, and each statement score ranged from 1-4. The total range of scores are 11-44. Higher SRS scores are associated with greater ASD-specific social difficulties.

2.2.1.2. *New method*

The SRS-S was adapted so that each statement could be completed for the two conditions at the same time: with and without self-perceived mild seizure activity. No wording of the assessment tool was modified. Participants were instructed to rate their statements twice, once 'without' and once 'with' self-perceived mild seizure activity. To do this, a second rating column was added and the two columns were labelled at the top for each condition, the left scoring column required a rating for the 'without' condition, and the right column required a rating for the 'with' condition. For example, after reading the first statement "I avoid eye contact with other people," a participant may enter into the first scoring column [for the "without" condition] the response: *1:slightly true*, and enter into the second scoring column [the "with" condition] *3:very true.* However, if the participant believed that there was no change in behaviour, the response for the second column would be the same *1:slightly true*, and if there was a decrease in behaviour, the response would be *0:False, not at all true.* The new method required participants to self-reflect on their behaviour with and without seizure activity at the same time for each statement, and report whether it changed or not. Self-reporting was only possible for some participants with epilepsy, and participants were not excluded if they did not provide responses for the second condition.

2.2.1.3. *Design.* The study was conducted as a mixed-design. The independent variable was group: adults with epilepsy and a control group. The dependent variable was score, for one or two conditions: without self-perceived seizure activity and with self-perceived seizure activity (group with epilepsy only).

2.2.2. *Experiment 2.*

The RBS-R was provided in paper format and digital format. Participants were provided with the following: i) personal details form, ii) RBS-R and instructions, iii) a feedback form.

2.2.2.1. *The Repetitive Behavior Scale-Revised.*

The RBS-R is a rating scale for measuring the presence and severity of restricted, repetitive behaviours, and designed to provide a quantitative, continuous measure of repetitive behaviours, and has been found to predict the severity of ASD and characterise the disorder [30]. The RBS-R consists of 6 subscales: Stereotyped Behaviour, Self-injurious Behaviour, Compulsive Behaviour, Ritualistic Behaviour, Sameness Behaviour, and Restricted Behaviour. The RBS-R has high inter-rater reliability and internal consistency. The shortened version consists of 12 items related to the subscale 'Sameness

Behaviour', measuring resistance to change and insistence on sameness. Participants self-rated their response on a 4-point Likert Scale ranging from 0-3. The total range of scores is 0-36. There were no missing data however, the most recent data was included for analysis for one participant who responded twice, [n=1]. The new method was employed for the RBS-R as in Experiment 1, *see section 2.2.1.2.*

2.2.2.2. Design. The experiment was conducted as a mixed-design. The independent variable was group: adults with epilepsy and a control group. The dependent variable was score, for one or two conditions: without self-perceived seizure activity and with self-perceived seizure activity (group with epilepsy only).

2.3. Procedure.

2.3.1. Experiment 1.

Participants were invited to take part in a study investigating cognition and behaviour in adults with epilepsy and those without epilepsy. Participants were provided with the SRS-S and invited to rate their behaviour by responding to the statements designed to identify social reciprocal interaction deficits and other autistic characteristics. Participants were invited to complete the SRS-S in their own time.

2.3.2. Experiment 2.

Participants were invited to take part in a study investigating cognition and behaviour in adults with epilepsy and those without epilepsy. Participants were provided with the RBS-R and invited to rate their behaviour by responding to the statements designed to identify repetitive behaviours, specifically sameness behaviours. Participants were invited to complete the RBS-R in their own time.

2.3.3. Statistical methods.

Comparisons were undertaken using SPSS version 14.2 for Windows, and significance level was set a conventional level of 5%.

2.3.4. Ethical considerations.

The research was approved by the University of Bath, Department of Psychology Ethics Committee.

3. Results

3.1 Experiment 1

Social Responsiveness Scale-Shortened

Analysis explored group differences for the first condition: 'without self-perceived seizure activity'. Data was positively skewed and this was not correctable by square root or log transformation. Levene's test confirmed homogeneity of variance ($p>.05$). The Mann-Whitney U test revealed a significant difference between the adults with epilepsy (*mean*=19.2, SD=6.1) and adults without epilepsy (*mean*=14.6, SD=3.9) (U=431.0, Z=-3.01, p=.003) yielding a large effect size (Cohen's *d*=0.89, (see Figure 5).
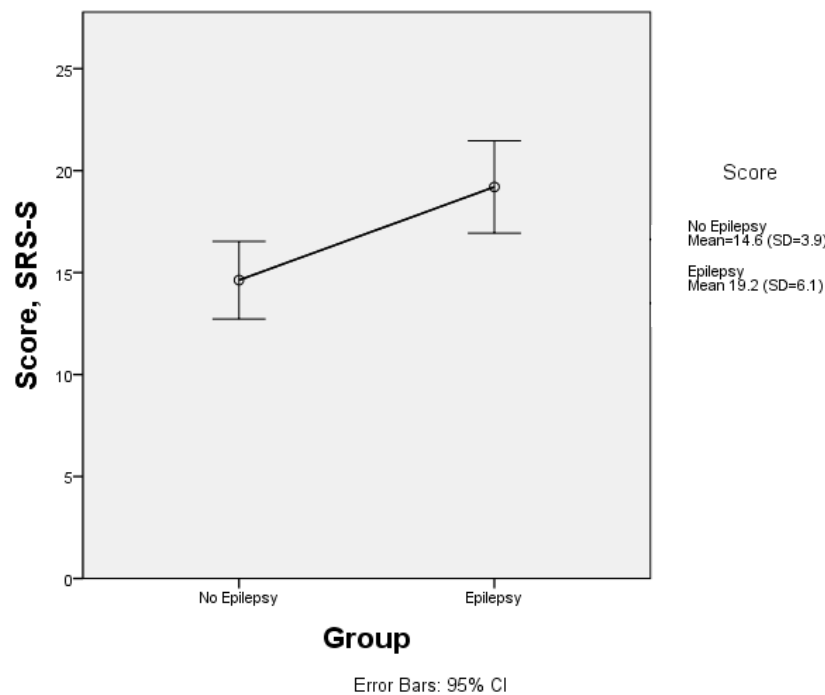

Figure 5. Social Responsiveness Scale-Shortened score by group.

Analysis explored differences between conditions for adults with epilepsy who had completed the second condition (with self-perceived seizure activity) *n*=13. The Wilcoxon non-parametric paired-samples signed-ranks 'exact' test was selected, as negatively skewed data were not correctable. There was a significant difference, adults with epilepsy scored significantly higher for the 'self-perceived seizure activity' condition (*mean*=28.0, SD=8.6) than the 'without self-perceived seizure activity' condition (*mean*=19.2, SD=6.7), z=-2.83, p=.005, r=-.55, (see Figure 6).
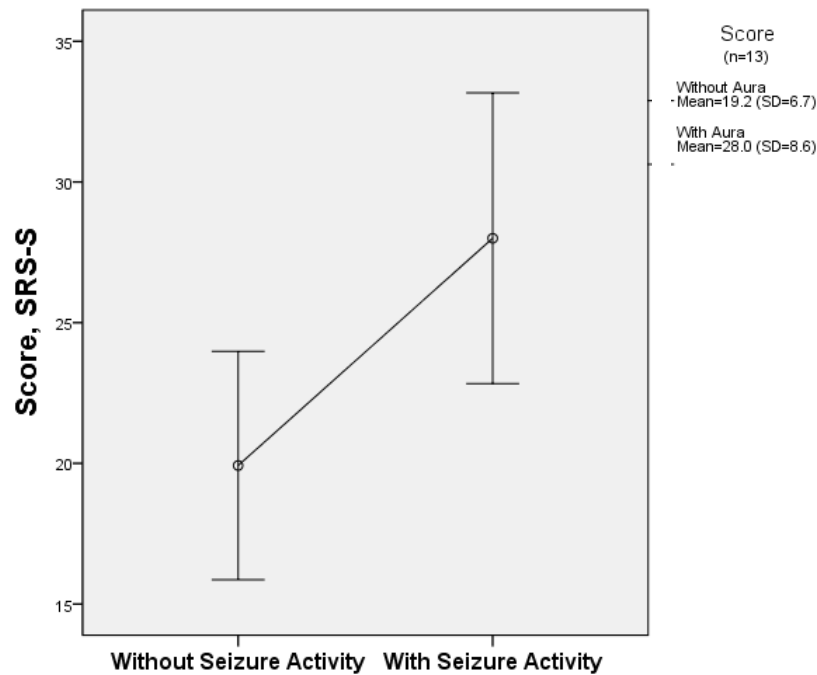
Figure 6. Social Responsiveness Scale-Shortened score for 'with self-perceived seizure activity' and 'without self-perceived seizure activity' conditions.

Anti-Epileptic Drugs

As hypothesized, a relationship was expected between AED control and score, with AEDs reducing social components of autistic characteristics. A Spearman's rho was conducted to explore this relationship. Participants reported currently taking AEDs [n=69], not taking AEDs, [n=2] and unknown, [n=5]. There was a non-significant trend towards higher SRS-S scores in those who rated their AEDs as less effective for the 'without self-perceived seizure activity' condition n=16, r=-0.43, p=0.097, and a significant positive relationship for the 'with self-perceived seizure activity' condition n=58, r=-0.40, p=0.009. Notably, most adults did not complete the 'without' condition and chose instead to only rate their behaviour for the 'with' condition, *see Limitations*.

Chronic epilepsy

A Pearson's correlation coefficient was conducted to explore the effect of 'years of epilepsy' on score for adults with epilepsy who reported this, *n*=51. There was a non-significant trend towards higher SRS-S scores in those with more chronic epilepsy for the 'without self-perceived seizure activity' condition *n*=51, *r*=0.39, *p*=0.086, and a significant positive relationship in the same direction for the 'with self-perceived seizure activity' condition *n*=36, *r*=0.34, *p*=0.044.

3.2 Experiment 2

Repetitive Behavior Scale-Revised.

Analysis explored group differences for the first condition: 'without self-perceived seizure activity'. Data was positively skewed and this was not correctable by square root or log transformation. Levene's test confirmed homogeneity of variance (*p>.05*). The Mann-Whitney U test revealed no group difference in score (*U*=573.5, *Z*=-1.24, *p*=0.215, *n.s*), see Table 7.

Analysis explored differences between conditions for adults with epilepsy who had completed the second condition (self-perceived seizure activity) *n*=9. Kolmogorov-Smirnov test revealed normal distribution for scores (*p>.05*). There was no significant difference for score (*t*=-0.964, df=8, *p*=0.36, *n.s*), see Table 7.

		Score		
	Mean (SD)	Range	*Sig.*	
Controls *n*=21	4.43 (5.86)	0-16	*p*=0.215, *n.s.*	
Epilepsy *n*=47 '*Without*'	6.38 (7.39)	0-27	*p*=0.215, *n.s.*	
(*n*=9) '*With*'	7.89 (6.94)	0-17	*p*=0.36, *n.s.* +	

+ *Between Conditions*

Table 7. Repetitive Behavior Scale-Revised score by group

Experiments 1 and 2 Scores

Pearson's correlation coefficient was used to explore the relationship between social and repetitive behaviours for the 'without self-perceived seizure activity' condition, for participants who completed both Experiments 3 and 4, measured in SRS-S and RRB scores. A significant relationship was found

for adults without epilepsy (n=21) r=0.56, p=0.045, and a significant relationship was found for adults with epilepsy (n=13) r=0.77, p=0.002. Pearson's correlation coefficient was used to explore the relationship between social and repetitive behaviours for the 'with self-perceived seizure activity' condition. There was no significant difference for adults with epilepsy (n=15) r=0.38, p=0.462.

4. Discussion

In our previous study, higher autistic traits were found to be reported in adults with epilepsy compared to adults without epilepsy [6]. In the current study, we aimed to explored the extent to which ASD characteristics were found in adults with epilepsy, and we explored whether self-reported seizure activity were related to changes in these behaviours.

As hypothesized, significantly higher scores for the SRS-S were found in adults with epilepsy than controls. Scores were significantly higher for self-perceived seizure activity than they were perceived to be interictally. A relationship was found between self-rated SRS-S scores and AED effectiveness reported for self-perceived seizure activity, good AED control was related to fewer ASD characteristics; however this finding is tentative and further investigation between AEDs and severity of autistic characteristics is warranted. No relationship was found between self-rated SRS-S scores and AED effectiveness reported for the interictal condition. Alternatively, this relationship may reflect a direct relationship between more severe intractable epilepsy and more severe behavioural impairment. Further, a relationship was found between SRS-S scores and years of epilepsy, those with chronic epilepsy reported a more severe presentation of ASD characteristics. None of the participants in this study reporting having a diagnosis of an ASD.

These findings suggest a possible relationship between having a diagnosis of epilepsy and autistic characteristics in adults who have no ASD diagnosis. This is consistent with our previous research employing the AQ. Together, findings of both higher AQ scores and higher SRS-S score in adults with epilepsy is consistent with other research demonstrating a significant positive relationship between SRS-S and AQ scores [22]. Notably, Happé and colleagues emphasise that the full scale SRS is consistent with the notion of a broader autism phenotype [31]. Adults with epilepsy reported that seizure activity worsened their perception of their autistic characteristics on the SRS-S but not the RBS-R. Further research is needed employing the full-scale SRS to uncover whether these difficulties are solely specific to ASD characteristics or due to a more general social impairment [32]. Further research is needed to examine the extent to which self-perceived mild seizure activity has a role in disrupting normal social and non-social processes.

These experiments employed self-rated measures, and further empirical studies are needed to examine the extent to which other psychosocial factors impact on social difficulties in people with epilepsy. Our previous study showed the presence of autistic traits which are considered to be heritable [6]. Consistent with this, measures on the full-scale SRS are highly heritable [17]. The results from Experiment 2 showed no difference in sameness behaviours between adults with epilepsy and controls. In contrast, a strong correlation was found between RBS-R and SRS-S scores in adults with epilepsy, which suggest a relationship between autistic characteristics measured by both shortened scales employed in this study.

The new method employed in this study suggests that some adults with epilepsy can provide important information about their own behaviour by employing a method which allows the adult with epilepsy to discriminate between perceived mild epileptic seizure and non-seizure activity. The meaningfulness of this new measure should be borne out through thorough investigation of what abilities are retained in adults during their self-perceived mild seizure activity; a discrimination needs to be sought between what adults with epilepsy perceive are behavioural characteristics which may worsen during mild seizure activity. Whether adults with epilepsy would not want to engage in a socially reciprocal manner, or whether they lack the social cognitive ability to engage during mild seizure activity remains to be determined through empirical evidence. The argument that all behaviours may be perceived to worsen during mild seizure activity and thereby nullify the usefulness of this method was not upheld by the findings of Experiment 2, for which no significant differences were found. However, due to the limitations of these shortened assessment tools and their applicability to the new method, further research is needed to establish the usefulness of the new method for discerning the impact on self-perceived mild seizure activity. This could lead to greater understanding of adults with epilepsy and any seizure-related changes in behaviour that may be expected to occur.

Together, this initial investigation of whether a new method can be employed for psychological assessment in adults with epilepsy supports the usefulness of employing this method to elicit information on behavioural changes during mild seizure activity.

4.1 Limitations

Confounding variables known to be associated with self-reports on symptom inventories such as education level and level of cognitive functioning were not investigated for either group. No ASD diagnostic evaluation was conducted for the epilepsy group, and it is unknown whether any participant had an undiagnosed ASD. No group were investigated for other co-morbid diagnoses. Both assessment tools were non-standardised shortened tools.

Experiment 1 lacked participants who completed both conditions, and more took part in the 'with self-perceived seizure activity' condition than the 'without self-perceived seizure activity' condition, thereby limiting the power of analysis between conditions. It is unclear why this occurred, although one explanation may be that epilepsy participants did not read the full instructions to rate each statement twice, and mistakenly believed that they only needed to complete the 'with' self-perceived mild seizure activity condition. This may result from these participants reading prior information that this study aimed to explore their mild seizure activity. It may be argued that some adults with epilepsy may find it difficult to distinguish their sameness behaviours during the 'with self-perceived seizure activity' condition which may present as a symptom of the epileptic seizure itself, as seizures are stereotypic events.

One limitation of employing the new method is the assumption that behaviour in epilepsy is not a continuum but is a dichotomy between seizure and non-seizure activity. This study attempts to offer the next best method based on current evidence until there is further consensus for self-reporting about self-perceived mild seizure activity in these two conditions. This method could be appropriate for psychological assessment during research into epilepsy, and supports the notion that investigations of mild epileptic activity in people with epilepsy could yield important information about alterations in their daily behaviour. The new method is limited to adults who are able to respond to questions about their self-perceived mild seizure activity, and make comparisons to their behaviour without self-perceived mild seizure activity.

5. Conclusion

This study aimed to establish the extent of autistic characteristics in a heterogeneous group of adults with epilepsy. The results suggest that adults with epilepsy have higher autistic characteristics than adults without epilepsy. The severity of these characteristics reported by adults with epilepsy were perceived to be related to their seizure activity and anti-epileptic drug effectiveness. Despite the presence of these characteristics, adults with epilepsy were no different to adults without epilepsy on measures of sameness behaviours, a component of rigid and repetitive behaviours. The extent to which the self-reported social differences in adults with epilepsy are related to a social cognitive dysfunction or the psychosocial impact of epilepsy has yet to be determined.

References

1. Clarke, D.F., et al., *The Prevalence of Autistic Spectrum Disorder in Children Surveyed in a Tertiary Care Epilepsy Clinic.* Epilepsia, 2005. **46**(12): p. 1970-1977.
2. McLellan, A., et al., *Psychopathology in children with epilepsy before and after temporal lobe resection.* Developmental medicine and child neurology, 2005. **47**(10): p. 666-672.
3. Matsuo, M., et al., *Frequent association of autism spectrum disorder in patients with childhood-onset epilepsy.* Brain and Development, 2010. **32**(9): p. 759-63.
4. *American Psychiatric Association: Diagnostic and statistical manual of mental disorders.* Vol. 4th edition, text revision. 2000, Washington, DC: American Psychiatric Association.
5. Tuchman, R. and I. Rapin, *Regression in Pervasive Developmental Disorders: Seizures and Epileptiform Electroencephalogram Correlates.* Pediatrics, 1997. **99**(4): p. 560-566.
6. Wakeford, S., et al., *Autistic characteristics in adults with epilepsy.* Epilepsy Behav, 2014. **41**: p. 203-7.
7. Spence, S.J. and M.T. Schneider, *The role of epilepsy and epileptiform EEGs in autism spectrum disorders. Pediatric Research.* Pediatric Research, 2009. **65**(6): p. 599-606.
8. Volkmar, F., *Understanding the social brain in autism.* Developmental Psychobiology, 2011. **53**(5): p. 428-34.
9. Schacher, M., et al., *Mesial Temporal Lobe Epilepsy Impairs Advanced Social Cognition.* Epilepsia, 2006. **47**(12): p. 2141-2146.
10. Hermann, B. and A. Jacoby, *The psychosocial impact of epilepsy in adults.* Epilepsy & Behavior, 2009. **15**(2): p. S11-S16.
11. Schacter, S., G.L. Holmes, and D. Kasteleijn-Nolst Trenite, *Behavioral aspects of epilepsy: principles and practice* 2008, New York: Demos Medical Publishing L.L.C.
12. Austin, J.K., M.W. Risinger, and L.A. Beckett, *Correlates of behaviour problems in children with epilepsy.* Epilepsia, 1992. **33**(6): p. 1115-1122.
13. Jokeit, H., *12. Social cognition in patients with temporal lobe epilepsies.* Epilepsy and Behavior, 2010. **17**(4): p. 582-583.
14. McCagh, J., J.E. Fisk, and G.A. Baker, *Epilepsy, psychosocial and cognitive functioning.* Epilepsy Res, 2009. **86**(1): p. 1-14.
15. Rantanen, K., et al., *Social competence of preschool children with epilepsy.* Epilepsy & Behavior, 2009. **14**(2): p. 338-343.
16. Di Martino, A. and R.F. Tuchman, *Antiepileptic drugs: affective use in autism spectrum disorders.* Pediatric Neurology, 2001. **25**(3): p. 199-207.
17. Constantino, J.N., et al., *Validation of a Brief Quantitative Measure of Autistic Traits: Comparison of the Social Responsiveness Scale with the Autism Diagnostic Interview-Revised.* Journal of Autism and Developmental Disorders, 2003. **33**(4): p. 427-433.
18. Rutter, M., A. Bailey, and C. Lord, *The Social Communication Questionnaire*. 2003.
19. Brosnan, M., E. Chapman, and C. Ashwin, *Adolescents with autism spectrum disorder show a circumspect reasoning bias rather than 'jumping-to-conclusions'.* Journal of autism and developmental disorders, 2014. **44**(3): p. 513-20.
20. Bölte, S., et al., *Autistic Traits and Autism Spectrum Disorders: The Clinical Validity of Two Measures Presuming a Continuum of Social Communication Skills.* Journal of Autism and Developmental Disorders, 2011. **41**(1): p. 66-72.
21. Constantino, J.N. *Social Responsiveness Scale, Second Edition (SRS-2): Product Description.* Pearson Clinical 2012 [cited 2015 July 8].
22. Kanne, S., S. Christ, and A. Reiersen, *Psychiatric Symptoms and Psychosocial Difficulties in Young Adults with Autistic Traits.* Journal of Autism and Developmental Disorders, 2009. **39**(6): p. 827-833.
23. Campbell, M., et al., *Stereotypies and tardive dyskinesia: abnormal movements in autistic children.* Psychopharmacology Bulletin 1990. **26**(2): p. 260-266.
24. Prior, M. and M. Macmillan, *Maintenance of Sameness in Children with Kanner's Syndrome.* Journal of Autism and Childhood Schizophrenia, 1973. **3**(2): p. 154-167.
25. Hoppe, C., A. Poepel, and E. Elger Christian, *Epilepsy: Accuracy of Patient Seizure Counts.* 2007. **64**(11): p. 1595-1599.

26. Krishnamoorthy, E.S., *The Evaluation of Behavioral Disturbances in Epilepsy.* Epilepsia, 2006. **47**(s2): p. 3-8.
27. Engel, J., *Surgical Treatment of Epilepsies*. 2nd Edition ed. 1993, New York: Raven Press.
28. Reiersen, A.M., et al., *Evidence for shared genetic influences on self-reported ADHD and autistic symptoms in young adult Australian twins.* Twin Research and Human Genetics, 2008. **11**(6): p. 579–585.
29. Brosnan, M.J., L.R. Gwilliam, and I. Walker, *Brief report: the relationship between visual acuity, the embedded figures test and systemizing in autism spectrum disorders.* Journal of autism and developmental disorders, 2012. **42**(11): p. 2491-7.
30. Bodfish, J.W., et al., *Varieties of Repetitive Behavior in Autism: Comparisons to Mental Retardation.* Journal of Autism and Developmental Disorders, 2000. **30**(3): p. 237-243.
31. Happe, F., A. Ronald, and R. Plomin, *Time to give up on a single explanation for autism.* Nature Neuroscience, 2006. **9**(10): p. 1218-1220.
32. Chin, R.F., et al., *Outcomes of childhood epilepsy at age 33 years: A population-based birth-cohort study.* Epilepsia, 2011. **52**(8): p. 1513-1521.