The relationship between subjective and objective cognitive functioning in epilepsy and the role of psychological distress

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To my family and friends, I owe more gratitude than I can express for making sure I stay a whole person. Thank you for being with me each day.

Contents

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Thesis Overview

Epilepsy is the fourth most common neurological condition globally (World Health Organisation, 2006) affecting approximately 1 in 103 people (Joint Epilepsy Council, 2005). It is a diverse term, encompassing over forty types of epilepsies, many types of seizure and varies significantly as to its cause and responsiveness to treatment (Berg et al., 2010). Typically, it is a chronic condition characterised by repeated seizures, which can be focal, affecting a specific part of the brain such as the frontal lobes, or general, in which most or all of the brain is affected. Although the cause of epilepsy is neurological, understanding further the psychological, behavioural and social effects of epilepsy is an important area of research, due to the significant impact these can have upon the lives of people with epilepsy (PWE) (Suurmeijer, Reuvekamp, Aldenkamp, 2001).

Many PWE demonstrate cognitive difficulties in areas such as executive functioning, attention, learning and memory (van Rijckevorsel, 2006). The high prevalence of cognitive difficulties in this population and frequent reporting of cognitive deficits from PWE suggest that this area warrants further investigation (Loring & Meador, 2012). There has been increased debate about a potential discrepancy between the cognitive abilities some PWE perceive themselves to have and their cognitive ability when assessed using neuropsychological tests (Banos et al., 2004). It is purported that psychological distress may have some role to play in this discrepancy (Liik, Vahter, Gross-Paju & Haldre, 2009). Depression and anxiety, which are experienced more frequently by people with epilepsy (Sherman, 2009), have been associated with susceptibility to higher levels of perseverative thinking (a type of repetitive negative thinking often seen transdiagnostically in anxiety and depression) (Ehring & Watkins, 2009), and reduced attentional control (the ability to direct concentration and focus, often impaired in PWE) (Derryberry & Reed, 2002).

This thesis seeks to establish the extent of the relationship between subjective and objective measures of cognitive functioning in PWE and the potential role of anxiety and depression. It then examines the role of attentional control and repetitive negative thinking; psychological mechanisms potentially affecting the relationship between objective and subjective measures of cognitive functioning.

Chapter 1 of this thesis systematically reviews the literature to determine the relationship between PWE's self-reports of their cognitive abilities and the results of attention and executive functioning assessments, deemed 'objective' measures. It also seeks to describe the extent to which psychological distress is associated with either of these variables. The systematic review demonstrates that most studies found no significant relationship between objective and subjective measures. It was not possible to draw conclusions regarding whether PWE tended to over- or under-estimate their abilities from the results of the studies. What was apparent, however, was that psychological distress was consistently associated with participants' self-reported cognitive abilities.

Chapter 2 presents a cross-sectional study with PWE that draws upon the findings and implications of the review and develops them. This empirical study finds a correlation between objective and self-reported cognitive functioning in participants with a diagnosis of epilepsy, which would not have been expected from the systematic review. When examining this further, psychological distress and repetitive negative thinking are both found to be statistically significant moderators of the relationship between objective and self-reported cognitive functioning. Attentional control, although correlated with psychological distress, does not moderate the relationship between objective and subjective measures of cognitive functioning.

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Chapter 1: The relationship between objective measures of attention and executive functioning and subjective cognitive functioning and the role of psychological distress in people with epilepsy: A systematic review.

For submission to Epilepsy and Behavior, author guidelines found in Appendix A

Abstract

Objective: Clinicians often rely upon self-reports of cognitive difficulties when deciding whether to refer patients for further neuropsychological assessment and in making treatment decisions. However, a recent literature review concluded that memory impairment was over-estimated by participants with epilepsy in six of the fifteen studies reviewed, with no significant discrepancy between self-reported and objective memory measures in eight of the studies. It found that perceptions of memory abilities were often more closely related to a person's experience of psychological distress than to objective measures. To date, little consideration has been given to how closely self-reports of cognitive abilities resemble objective measures of attention and executive functioning, despite people with epilepsy often reporting difficulties within these domains. This systematic review, therefore, draws together and evaluates research regarding the relationship between self-reported and objective measures of attention and executive functioning and their association with psychological distress for people with epilepsy.

Method: Embase, MEDLINE, PsycINFO and Scopus were systematically searched for studies published prior to February 2017 comparing objective attention and executive functioning and self-reported cognitive functioning in adults with epilepsy. Eleven studies were identified and a narrative synthesis was carried out.

Results: Eight of the eleven studies reported no relationship between objective and self-report measures of attention and executive functioning. One study showed mixed results depending upon the measure of objective functioning used, and two found a statistically significant relationship between self-reported and objective measures of attention and executive functioning. Higher levels of psychological distress were associated with lower self-

reported cognitive functioning within seven of the nine studies that examined this relationship.

Conclusions: This review finds evidence for a lack of a relationship between results of self-report and objective measures of attention and executive functioning. Additionally, people with epilepsy's perceptions of their cognitive functioning appears to be closely associated with the experience of depression or anxiety. Methodological issues are highlighted, particularly a potential recruitment bias of most studies using outpatient clinics, and assessment measures lacking psychometric validation with people with epilepsy. The findings suggest that reducing psychological distress may have a role in increasing the relationship between objective and self-reported attention and executive functioning abilities.

Keywords

Epilepsy, attention, executive functioning, self-reports, psychological distress.

1. Introduction

1.1. Epilepsy and cognitive functioning

Epilepsy is increasingly recognised as directly or indirectly impacting upon the cognitive abilities of people with epilepsy (PWE), and the International League Against Epilepsy incorporates cognitive effects as an integral aspect in defining the condition [1]. Impairments to memory, language, intellect [2], attention and executive functioning [3, 4] and processing speed [5] have been shown in around 30-75% of PWE [6-8]. Cognitive impairment can be caused by several factors, including epilepsy origin, epilepsy duration, type of seizure [9] and treatment [10]. Additionally, it is increasingly believed that psychosocial factors may also be an important consideration in understanding cognitive functioning in PWE [11]. For some individuals, the perception of experiencing cognitive deficits can impinge significantly upon confidence and self-esteem [11]. For these reasons, within the document *Indications and Expectations for Neuropsychological Assessment in Routine Epilepsy Care* from the International League Against Epilepsy, the importance of early detection and intervention of cognitive difficulties with PWE is highlighted [12].

1.2. Objective and self-reported cognitive functioning

The first indication that further neuropsychological assessment is necessary is often the reporting of cognitive difficulties by the person with epilepsy. However, a recent review of the literature found that, of the fifteen studies reviewed, within six studies PWE consistently under-estimated their memory when compared to neuropsychological testing, although eight studies found no discrepancy between self-reports and results of objective memory assessment [13]. This review only examined memory; however, another recent study found that, following a first seizure, 49% of participants reported overall cognitive decline which was

not indicated by neuropsychological assessment [14]. There may, therefore, be a similar lack of association between objective and self-reported cognitive abilities in other domains of cognitive functioning in which PWE perceive difficulties, for example attention and executive functioning [15]. Attention and executive functioning are two cognitive domains which are strongly inter-related and impact upon goal-directed proficiencies necessary for daily living skills [16]. Executive functioning is a broad concept which encompasses skills carried out within the frontal lobes, including planning, reasoning, initiation and inhibition, working memory, self-monitoring and self-regulation [16]. They can have a significant impact upon the lives of PWE [17, 18] and, due to their broad impact, deficits within these areas may actually be reported as difficulties experienced in other domains of functioning [19]. Therefore, it is queried whether a similar discrepancy exists between neuropsychological measures of attention and executive functioning and self-report measures. To date, no systematic review has brought together evidence on this relationship.

Cognitive deficits, whether captured by objective testing and/or self-reporting, can impact upon employment, education, social life, relationships, self-esteem and hopefulness [20]. As social outcomes can also be poor for PWE assessed as having average cognitive abilities [21], interventions which reduce perceived cognitive deficit may have a role in increasing quality of life for PWE.

1.3. Psychological distress

Hall et al. (2009) suggest that anxiety and depression may distort the relationship between objective measures and self-reports of memory [13]. The potential importance of psychological distress in understanding the relationship between self-report and objective measures has been indicated by studies finding mood to be highly correlated to self-reported

cognitive functioning [22, 23], although other studies have reported conflicting results [24]. Therefore, the role of psychological distress within the relationship between objective and self-reported cognitive functioning, particularly attention and executive functioning, remains unclear.

1.4. Study aims

Clinicians often rely upon self-reporting to identify cognitive difficulties. However, PWE's objective memory results and self-reports show a discrepancy in some studies, with anxiety and depression potentially implicated. Although they may not reflect neuropsychological results, perceptions of experiencing cognitive deficit can have wide-ranging impacts upon PWE's lives. Executive functioning and attention are important domains of cognitive functioning, impacting upon goal-directed cognitive and psychosocial skills. Therefore, this systematic review aims to address the following questions:

1) What is the nature of the relationship between objective and self-report measures of attention and executive functioning in PWE?

2) How is psychological distress related to self-reported cognitive functioning and objective measures of attention and executive functioning?

2. Method

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement [25] was used as a guideline for conducting and reporting this systematic review.

2.1. Inclusion criteria

The studies had to meet the criteria pertaining to the Key Question [26]: What is the nature of the relationship between objective and self-report measures of attention and executive functioning in PWE? This guided the following inclusion criteria to be deemed as necessary by the research team:

a. Participants between the ages of 18-65, with a diagnosis of epilepsy. Excluding studies with participants who had undergone epilepsy surgery or had co-morbid neurological conditions.
b. Objective attention and executive functioning must be compared to self-reported cognitive functioning.
c. At least one objective measure of attention or executive functioning and a measure of self-reported cognitive functioning.
d. Original, quantitative studies available in English and published within a peer-reviewed journal.

2.2. Search strategy

A search was conducted for studies meeting the above criteria up to February 2017 using Embase, MEDLINE, PsycINFO and Scopus. Key words and controlled vocabulary from databases were used within the search strategy to encompass the criteria (Table 1). Duplicate articles were removed and titles and abstracts of the remaining studies were reviewed by the

first reviewer (LM). Where the abstract did not show how closely the study matched the criteria the full article was reviewed. The full article was then reviewed for all studies with abstracts which had appeared to match the inclusion criteria, using a criteria checklist by LM (Appendix B). A second person (JS) reviewed the full article of six randomly selected studies using the criteria checklist to assess inclusion criteria were met.

Table 1: Search strategy terms

Search Strategy
1. Epilepsy
2. Subjective cogniti* Perceived cogniti* Self-assessed cogniti* Self-rated cogniti* Subjective attention Perceived attention Self-assessed attention Self-rated attention Performance-complaint
3. Objective cogniti* Objective assess* Psychometrics Neuro* assessment Neuro* deficits Concentration Attention Executive function*
4. NOT child NOT juvenile
Final strategy: 1 AND 2 AND 3 NOT 4

2.3 Quality appraisal

Two reviewers (LM and JS) independently assessed the quality of each study using the 16-Item Quality Assessment Tool (QATSDD) (Appendix C) [27]. This tool has good reliability and validity [27]. Aspects of a study's design, methodology, analysis and conclusions were rated from 0 ('the study does not do this at all') to 3 ('the study does this in a complete way').

Each study's scores from the sixteen items were amalgamated to create an overall score which was converted into a percentage of the study's maximum possible score (Appendix D). The QATSDD does not describe what score would equate to a reasonable score, therefore for the purposes of this study the following descriptions were allocated: poor quality (<50%), acceptable quality (50-70%), good quality (≥71%).

2.4 Data extraction and synthesis

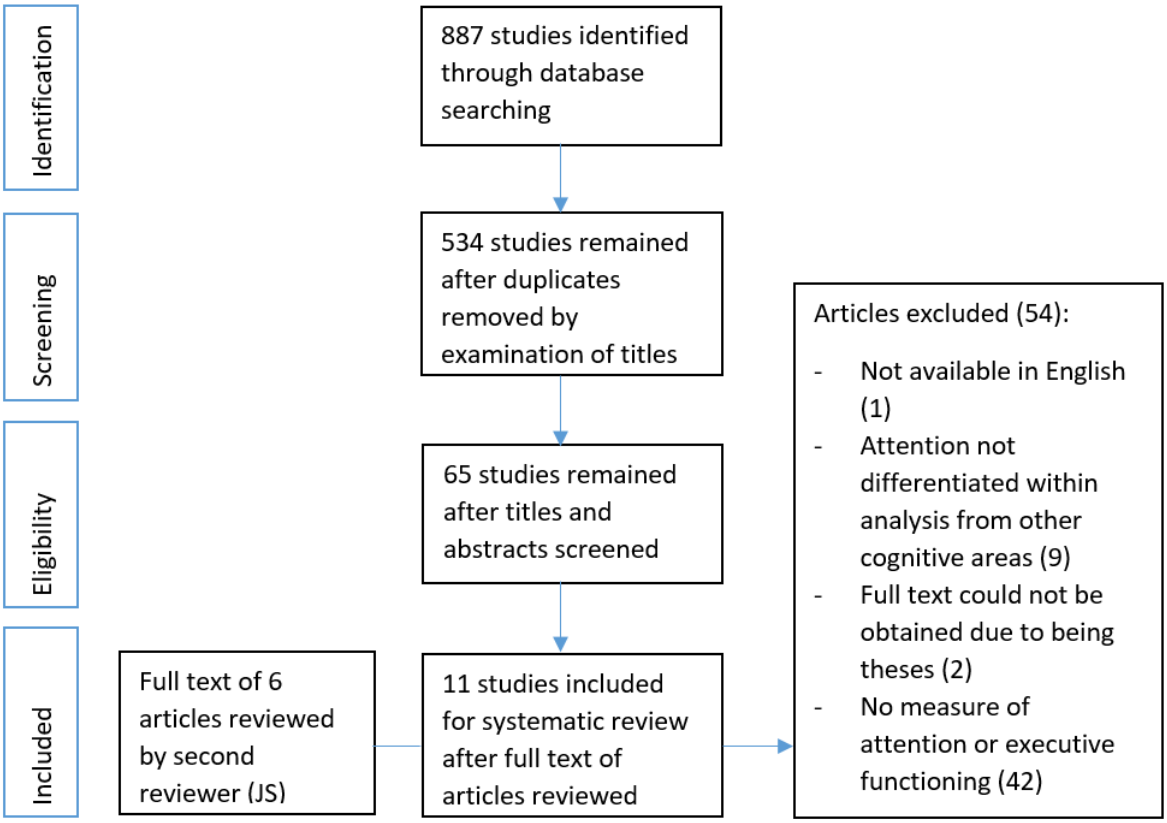
The data extracted from each study were: 1) author; 2) year; 3) number of participants; 4) type of epilepsy; 5) country of study; 6) objective measures of attention and executive functioning used; 7) measure of self-reported cognitive functioning; 8) key findings about the nature of the relationship between objective attention and executive functioning and subjective assessments (including unadjusted and adjusted reports of statistical association where available); 9) measures of psychological distress; and 10) key findings about the nature of the relationship between psychological distress and objective and self-reported cognitive functioning. The data were tabulated and a narrative synthesis carried out on all findings. Due to the disparate measures of objective and self-reported cognitive functioning and psychological distress used by the studies, and the lack of statistical output given by some, only a narrative analysis was possible.

3. Results

3.1. Search

A total of 887 studies were initially identified through database searching (Figure 1). After manually removing duplicates, 534 studies remained and their titles and abstracts were screened. This resulted in 65 studies being left for detailed consideration. The full texts of these papers were reviewed and 54 studies were subsequently excluded from the study as they did not fulfil the inclusion criteria. The remaining 11 studies were reviewed, quality assessed and data were extracted into a table (Appendix D). 9-10% (n=6) of the initial 65 were randomly selected and reviewed by a second reviewer (JS). Both reviewers independently concluded the same results regarding which studies met inclusion criteria.

Figure 1: Diagram of study selection process



3.2. Description of studies

The eleven studies included within this review were published between 2002 and 2016 and all used quantitative methodologies. The studies were published in the USA (n=3) [28-30], the Netherlands (n=1) [31], Germany (n=4) [7, 32-34], Estonia (n=1) [35], Portugal (n=1) [36] and the UK (n=1) [37].

For eight of the eleven studies, the relationship between objective measures and self-reports of cognitive functioning and psychological distress for PWE was the primary focus [28-31, 33, 35-37]. The focus of the remaining studies was the prevalence of cognitive deficits in new onset epilepsy [7], a comparison of the impact of different anti-epilepsy medication (AEDs) on cognition [32] and the validity of proxy reports of cognitive functioning in PWE [34].

3.3. Participants

Participants with epilepsy within the eleven studies totalled 1380 (range=16-498 [31, 32]; mean=125.5; SD=142.1) (Table 2). The mean age across the studies ranged from 34.6 [35] to 47 [7]; the weighted average age was 42.9. Participants in nine studies were recruited from specialist hospital outpatient clinics [7, 29, 31-37]. The recruitment method was unclear for two studies: one did not disclose this information [30] and the other simply stated that they recruited from patients “undergoing evaluation for medically intractable seizures” (p. 576) [28].

One study only included participants with temporal lobe epilepsy [28] and three only included those with focal epilepsies [29, 31, 36]. The remaining seven studies recruited participants experiencing a range of epilepsy types [7, 32-35, 37]. With regards to seizures, one study recruited only participants who had been seizure free for two years [31] and two did not report on seizure frequency [28, 33]. For the rest, means ranged from 4.1 seizures in the last six months [7] to 7.97 seizures per week [29].

Table 2: Participant characteristics of studies

Study	Sample size	Epilepsy Type
Banos et al. (2004)	Male:38 Female: 55	Type of epilepsy: 57 participants had left temporal lobe epilepsy (LTLE). 36 participants had right temporal lobe epilepsy (RTLE).
Engelberts et al. (2002)	Males: 11 Female: 5	All participants had well-controlled epilepsy, seizure free for two years, who had epilepsy for over 7 years but started after they finished high school. Type of epilepsy: 4 frontal lobe, 5 temporal lobe, 6 frontotemporal1 occipital.
Fargo et al., 2003.	Male: 22 Female: 23	Epilepsy type not specified
Helmstaedter et al. (2010)	Male: 238 Female:260	Epilepsy type not specified
Kampf et al., (2015)	Male: 16 Female: 24	Epilepsy type: 15 symptomatic focal, 21 cryptogenic focal and 4 idiopathic generalised epilepsies.
Karkoska et al., (2015)	34 participants. Male: 7 Female: 27	Epilepsy type: 2 simple partial, 20 complex partial, 7 simple and complex partial seizures, 5 generalised epilepsies.
Liik et al., (2009) ‘	Male: 25 Female: 37	Epilepsy type: 2 simple partial and complex partial, 5 complex partial, 28 complex partial and secondarily generalised seizures, 9 generalised seizures, 18 generalised tonic clonic seizures. 35 partial epilepsy, 10 TLE, 27 idiopathic generalised epilepsy
Marino et al., (2009)	Male: 116 Female: 76	Epilepsy type not specified
Meneses et al. (2009)	Male: 31 Female: 40	Epilepsy type: 47 temporal, 13 frontal, 9 frontotemporal, 2 frontoparietal.

Samarasekera et al. (2015)	Male: 38 Female: 44	Epilepsy type: 63 structural/ metabolic, 15 genetic generalised, 4 unspecified
Witt et al. (2012)	Male: 135 Female: 112	Epilepsy type: 119 symptomatic epilepsy, 27 cryptogenic epilepsy, 61 idiopathic epilepsy.

3.4. Methodological quality

The QATSDD was used to evaluate the quality of each paper. The Cohen's Kappa statistic for inter-rater agreement was 0.85, which is in the range of 'very good agreement'. The discrepancies were discussed and a decision collaboratively made as to the most appropriate score. The percentages of the total potential score assigned to the studies varied from 43% to 74%. Overall, two studies were judged to be of 'poor' quality, seven of 'acceptable' quality and two of 'good' quality (Appendix E).

One of the potential methodological limitations of the studies was that the ability of the studies to precisely estimate the relationship between objective and self-reported cognitive functioning was unclear, as only two studies reported a sample size calculation and recruited sufficient numbers of participants [36, 37]. The other studies did not report a sample size calculation and there was wide variation in participant numbers recruited by the studies reviewed.

Secondly, except for three studies [7, 36, 37], the validity and reliability of the objective and self-reported cognitive functioning measures used was not discussed. Additionally, two studies measured self-reported cognitive functioning using Likert scales developed specifically for the purposes of the studies, with psychometric data on the reliability and validity of these scales not reported [7, 32]. It is unclear, therefore, how valid or reliable a representation these measures provided of the participant's subjective cognitive

functioning. A further study made an adjustment to a previously standardised questionnaire by including extra questions, potentially affecting results in a way that is hard to predict [35].

Thirdly, eight of the studies made multiple comparisons within their data, for example breaking down a questionnaire or neuropsychological test into its separate subtests to use within their analysis, thereby increasing analyses [28, 29, 31, 33-36] and making a high number of correlations: 124 in one study [30]. This increases the likelihood of a Type I error, only two studies reported correcting for this [31] [29].

3.5. Question 1: The relationship between objective attention and executive functioning and self-reported cognitive functioning

3.5.1. Objective attention and executive functioning

All studies used face-to-face neuropsychological tests to assess objective attention and executive functioning (Table 3). The most commonly used tests were the EpiTrack (n=5) [7, 32-34, 37], a brief screening tool developed originally to track the effects of AEDs on attention and executive functioning in PWE, and the Stroop Colour-Word Test (n=4) [28, 30, 31, 34]. Other studies used subtests of the Wechsler Adult Intelligence Scale (WAIS) (Arithmetic and Digit Span [28, 29]; Spatial Span [29]), the Delis-Kaplan Executive Function System (Categoric Word Fluency Task [31]; Trail Making Tests [35]), Digit Cancellation Test [30] and Symbol Digits Modalities Test [35]. These assessments are widely used clinically with PWE, although there has been little examination of their psychometric properties when used with PWE.

Four studies used the results of individual tests as representations of attention or executive functioning [30, 31, 35, 36]. Two developed a composite measure of individual

performance on tests of Attention/Concentration [28, 29]. Those using the EpiTrack had an overall score generated from the EpiTrack's individual subtests [7, 32-34, 37].

One study compared objective attention and executive functioning scores, using the Stroop Test, to their matched control group. They found no impairments for PWE in two subtests; however, PWE's abilities were significantly reduced in the other two subtests [31]. Five studies using the EpiTrack compared the objective attention and executive functioning scores of PWE to the EpiTrack's normative scores. Mild impairment was found in 16% [32] and 19% of participants [7]. Evidence of significant impairment was found in 23.1% [33], 30.4% [7] and 38% [32] of participants. Significant impairment was also found in 34% of participants using one AED, 64% of those taking two AEDs and 71% of those using three or more AEDs [37].

Table 3: Studies reporting proportion of participants experiencing objective attention and executive functioning difficulties

Study	**Measure**	**Comparisons to norm**
Engelberts et al., (2002) [31]	Stroop Test	Compared to healthy matched controls. PWE statistically slower in Subtests I and II (F=7.686; F=11.59) No difference in Subtests III and IV (F=1.228; F=5.773).
Helstaedter & Witt (2010) [32]	EpiTrack	'Mild impairment': 16% 'Impairment': 38%
Kampf et al., (2015) [33]	EpiTrack	'Pathological': 23.1%

Study	Measure	Comparisons to norm
Samarasekera et al., (2015) [37]	EpiTrack	Participants experiencing 'significant impairment': 34% using one AED 64% using two AEDs 71% using three or more AEDs
Witt & Helmstaedter (2012) [7]	EpiTrack	'Mild impairment': 19.0% 'Marked impairment': 30.4%

Note: The EpiTrack is scored out of 45 points with the range for 'mild impairment' being 26–28 points and 'significant/marked impairment', 'pathological' or 'impairment' being ≤25 points [7, 32, 33, 37].

3.5.2. Self-reported cognitive functioning

In assessing participants' self-reported cognitive functioning, most studies used measures assessing cognitive functioning in general, rather than attention and executive functioning specifically. Two studies used Likert scales developed for the purposes of the study [7, 32] and one used a questionnaire developed from a previous study [39] with additional epilepsy-specific items [35]. The remaining eight used established questionnaires developed to assess self-reported cognitive functioning. This included the Multiple Abilities Self-Report Questionnaire (MASQ) [28], which has had concurrent validity assessed with people with temporal lobe epilepsy [40], and also the A–B Neuropsychological Assessment Schedule [37]. The latter questionnaire was designed for measuring patient-perceived impact of AEDs on cognition and there is evidence for its reliability and validity in PWE [41]. The Cognitive Failure Questionnaire was used in one study [31], although the psychometric properties of its use with PWE do not appear to have been examined. The three cognitive subscales (Memory, Language and Attention/Concentration) of the Quality of Life in Epilepsy Questionnaire (QOLIE-89) were used within two studies [29, 30]. The QOLIE-89 assesses quality of life specifically in PWE, with good reliability of the overall measure [42], although

this may be compromised when using three subscales, which had limited maximum scores and ranges. Three studies took place in countries which do not use English as a first language and used the c.I.-Skala [33], the Portuguese version of the Cognitive Functioning subscale from the ESI-55 [36] and the Fragebogen zur geistigen Leistungsfähigkeit (FLei) [34].

The proportion of participants reporting cognitive difficulties in the studies is shown in Table 4. Five of the eleven studies compared the self-reported cognitive functioning scores with normative data for the general population. The highest percentage of participants in a study reporting cognitive difficulty was Samarasekera et al. (2015) with 81.7% of their participants reporting 'high cognitive dysfunction' [37]. This was followed by Helmstaedter and Witt (2010) with 51% of PWE considering themselves to be mildly to significantly impaired [32] and 28.2% self-reporting a 'pathological' level of cognitive functioning within Kampf et al.'s (2015) study [33]. In another study, 24.7% considered their attention to be 'mildly impaired' and 4% perceived their attention as 'markedly impaired' [7].

Between-group differences were analysed within three studies and suggested that participants with right temporal lobe epilepsy reported more cognitive problems than those with left temporal lobe epilepsy [28]. PWE scored their cognitive abilities higher than participants with psychogenic non-epileptic seizures [29], but significantly worse than a healthy control group [31].

Table 4: Studies reporting proportion of participants who reported cognitive difficulties

Study	**Self-reported cognitive functioning measure**	**Comparisons to norm**
Engelberts et al., (2002) [31]	Cognitive Failure Questionnaire	Significantly lower scores in PWE compared to matched healthy controls (p=0.002, F=12.049)
Helstaedter & Witt (2010) [32]	Likert scale	'Impaired cognition': 51%

Study	Self-reported cognitive functioning measure	Comparisons to norm
Kampf et al., (2015) [33]	c.I.-Skala	'Pathological': 28.2%
Samarasekera et al., (2015) [37]	ABAS	'Cognitive dysfunction': 81.7%
Witt & Helmstaedter (2012) [7]	Likert scale	'Mildly impaired': 24.7% 'Markedly impaired': 4%

3.5.3. Association between self-reported and objective attention and executive functioning

All eleven studies analysed the relationship between objective attention and executive functioning and self-reported cognitive functioning. Eight reported no statistically significant relationship, two reported a statistically significant relationship and one showed a significant and non-significant result dependent upon whether the EpiTrack or the Stroop Test was used as a measure of attention and executive functioning (Table 5).

Of the nine studies reporting no statistically significant relationship, one study employed stepwise hierarchal regression. It showed that the objective attention/concentration composite did not account for a statistically significant amount of variance of self-reported cognitive functioning, although the statistical analysis output was not reported [28]. Five studies used correlational analyses and had individual *r* values ranging from r=-0.082 to r=0.22, showing no significant correlation between objective attention and executive functioning and self-reported cognitive functioning. These studies included three using a Pearson's correlation (r=0.10, p=0.40) [36], two of which did not report statistical analysis output [30, 31], and one study using linear regression, which separately compared both objective attention (r=0.115, p>0.05) and two subtests of objective executive functioning (r=-0.075; r=-0.082, p>0.05) to self-reports [35]. The last study employing

correlational analysis reported no significant correlations between objective and self-report measures of attention (r=0.22; r=0.10, p>0.05) and executive functioning (r=0.13, p>0.05) [34]. Mixed results were found for one study using stepwise linear regression, as participants with objective functioning classified as 'impaired' had greater concordance between objective and self-reported cognitive functioning (84.7%) than participants whose attention and executive functioning was 'unimpaired' (30.4%). However, overall, objective scores did not significantly predict self-reports [37]. One study using paired t-tests analysing whether objective and self-report scores were statistically different, found participants overestimated their attention (t[44]-5.71, p<.0001, d=1.11) [29]. The last study, using univariate ANOVAs, found that objective scores were concordant with self-reporting in 49.4% of participants, but that overall participants tended to overestimate their cognitive abilities [7].

Studies which found better scores on objective cognitive functioning tests to be correlated with higher self-reported cognitive abilities included one study showing a small positive correlation (r=0.20, p<0.05), which stated that significance was reached due to the large sample size [32]. Larger significant correlations were found for one study employing univariate linear regression (r=-0.33, p<0.04) [33], and another study, which previously found no relationship between scores on the Stroop Test and self-reported attention and executive functioning, found a significant relationship when comparing results of the EpiTrack to subjective attention (r=-0.37, p<0.05) and subjective executive functioning (r=-0.52, p<0.01) [34].

Table 5: Analyses of the relationship between objective attention and executive functioning and self-reported cognitive functioning

Study	Statistical analyses	Findings
Banos et al., (2004) [28]	Hierarchal regression: output not reported.	Objective attention and executive functioning did not predict self-report scores.
Engelberts et al., (2002)[31]	Pearson's correlation: output not reported.	No correlation.
Fargo et al., (2004) [29]	Paired t-tests: (t[44]-5.71, p<.0001, d=1.11).	Self-report scores significantly higher than objective scores.
Helstaedter & Witt (2010) [32]	Pearson's correlation: (r=0.20, p<0.05).	Objective and self-report scores significantly correlated.
Kampf et al., (2015) [33]	Univariate linear regression: (r=-0.33, p<0.04).	Significant relationship between objective and self-report scores.
Karkoska et al., (2015) [34]	Pearson's correlations: EpiTrack and self-reported attention (r=-0.37, p<0.05). EpiTrack and self-reported executive functioning (r=-0.52, p<0.01). Stroop Test and self-reported attention (r=0.22; r=0.10, p>0.05). Stroop Test and self-reported executive functioning (r=0.13, p>0.05).	Correlation between EpiTrack and self-report scores. No correlation between Stroop test and self-report scores.
Liik et al., (2009) [35]	Linear regression: Objective attention and self-reports *(r=0.115, p>0.05)* Objective executive functioning and self-reports (r=-0.075; r=-0.082, p>0.05).	No correlation.
Marino et al., (2005) [30]	Statistical output and analyses not reported.	No correlation.

Study	Statistical analyses	Findings
(As disclosed in [38])		
Meneses et al., (2009) [36]	Pearson's correlation: (r=0.10, p=0.4).	No correlation.
Samarasekera et al., (2015) [37]	Stepwise linear regression: 'Impaired' concordance: 84.7%. 'Unimpaired' concordance: 30.4%.	Higher concordance between self-report and objective scores for those with impaired objective attention and executive functioning levels. Overall no significant relationship.
Witt & Helmstaedter (2012) [7]	Univariate ANOVA: Objective scores concordant with self-report scores in 49.4% of participants.	Participants over-estimated their attention and executive functioning abilities.

3.6. Question 2: The relationship between objective and self-report measures and psychological distress

3.6.1. Psychological distress

All eleven studies included one or more measure of psychological distress. These included the WHO-5 [32] (n=1) which measures quality of life, but also has acceptable validity in screening for anxiety, although not depression, in PWE [43]. The Washington Psychosocial Seizure Inventory (WPSI) was also used [28] (n=1), which is a measure assessing epilepsy-specific psychosocial adjustment and has a scale regarding emotional adjustment. It has been found to have acceptable validity and reliability for PWE [44]. The Minnesota-Multiphasic Personality Inventory (MMPI-II), which is a personality assessment, was used by two studies, [28, 29]. The subtests of the MMPI-II, Depression, Schizophrenia and Psycasthenia, were used by both studies. There is some preliminary research into its validity in being used with PWE [45]. The Profile of Moods States (PMS) [29-31] (n=3), Self-Rating Depression Scale and State

Trait Anxiety Inventory (State Scale) [33] (n=1) and Short Form-36 Health Survey [31, 36] (n=2) were also employed which, although used clinically and during research with PWE, do not appear to have had their psychometric properties validated with people with epilepsy. Other measures used include the Hospital Anxiety and Depression Scale (HADS) [34, 37] (n=2), Beck Depression Inventory [35] (n=1) and Centre for Epidemiological Studies Depression Scale [30] (n=1) which have evidence of their validity in screening for depression in PWE [46, 47], although another study has disputed that the HADS has sufficient sensitivity in PWE [48]. One study did not use a standardised questionnaire but asked participants to rate on a scale their 'Psychic wellbeing' [7].

Participants in one study with left temporal lobe epilepsy reported more problems with emotional adjustment and mood than those with right temporal lobe epilepsy using the MMPI-II and WPSI [28]. When comparing PWE against a healthy control group another study found no difference in the mental health related quality of life [31]. No other studies commented on the proportion of participants experiencing clinical levels of psychological distress.

3.6.2. Relationship between self-reported cognitive functioning and psychological distress

Nine studies compared measures of psychological distress to self-reported cognitive functioning. Seven studies found a significant relationship, one found a mixed result and one found no significant relationship between the variables. The study which found mixed results showed that when using the WPSI and MMPI-II, only one subscale of the MMPI-II (Schizophrenia) significantly contributed to self-reported attention, using a regression analysis (R^2=0.39) [28]. The study, which found no significant relationship between measures

of mood and self-reported cognitive functioning, used correlational analysis, although it did not report the statistical output [31].

Using multiple regression, one study found a statistically significant result, showing that 42% (p<0.05) of variance of self-reported cognitive functioning was explained by anxiety and depression (p=0.04) [34]. A different study, also using a regression analysis, found slightly less variance of self-reported cognitive functioning explained by just depression (36%), although still a statistically significant result (p<0.05) [35]. Another study, which was deemed to be of high methodological quality using the QUATSDD, used stepwise regression and also found a significant relationship, reporting that self-reports of cognitive difficulties were predicted by depression (p=0.001) and anxiety (p=0.032) [37]. Using correlational analyses, one study reported that their composite of the PMS and MMPI-II had a significant negative association with self-reported ratings of attention (r=-0.54, p<0.0001), showing that PWE experiencing higher levels of psychological distress were more likely to report worse cognitive functioning [29]. This association between higher levels of psychological distress and self-reported worse cognitive functioning was mirrored in two other studies. One study showed significant positive correlations for self-reported cognitive functioning with both depression (r=0.65, p<0.000005) and anxiety (r=0.56, p<0.0007) [33], however was of 'low' methodological quality using the QUATSDD, and another, of 'acceptable' methodological quality, reported a positive correlation between anxiety and self-reports (r=0.57, p<0.001) [32]. However, both positive and negative significant correlations were found between 'mood' and self-reported cognitive functioning, for PWE using the AEDs lamotrigine and topiramate (r values ranging from -0.316 to 0.626, p<0.01) [30]. This study was within the range of 'low' methodological quality using the QUATSDD and the details reported by this study were very limited, therefore its findings should be interpreted with this caveat.

3.6.3. Relationship between objective attention and executive functioning and psychological distress

Five studies considered the relationship between objective attention and executive functioning and psychological distress. One study found there to be a relationship between higher levels of psychological distress and lower objective attention and executive functioning. Two studies found mixed results, one depending upon AED participants used and one depending upon objective measure used. The remaining two studies found no relationship between objective results and psychological distress.

A significant positive correlation between the 'mental health' component of the quality of life measure and objective attentional abilities was found in one study (r=0.29, p=0.01) [36] of 'acceptable' methodological quality, showing lower psychological distress indicated better objective cognitive functioning. Another study of 'acceptable' quality found a statistically significant difference between participants with high and low levels of depression for four of the five subtests of objective executive functioning, although it did not report statistical output [35]. The study showed that participants with fewer symptoms of depression performed better in two subtests of objective attention and executive functioning measures than those with more depressive symptoms and vice versa for the other two subtests. This study was also within the category of 'acceptable' methodological quality. Mixed findings were shown by Marino et al. (2009), who found no correlation between psychological distress and objective attention for participants taking lamotrigine as an AED, but did find a significant correlation between psychological distress and objective attention for those taking topiramate as an AED, although the study did not indicate directionality (r=0.349, p<0.005) and was within the range of 'low' methodological quality [30].

No relationship was found within two studies of 'acceptable' methodological quality, one comparing 'psychic well-being' with objective attention and executive functioning (r=-0.03, p>0.05) [7] and another comparing depression and objective attention and executive functioning (r=0.09, p>0.05) [32]. None of the two studies which were found to be of 'good' methodological quality investigated the relationship between objective cognitive functioning and psychological distress.

4. Discussion

The aim of this review was to examine the relationship between objective attention and executive functioning and self-reported cognitive functioning in PWE. The review also sought to examine the association of psychological distress with objective and self-report measures. Eleven studies were identified which matched the inclusion criteria. Overall, the review found evidence that self-reported cognitive functioning was not reflective of results of objective attention and executive functioning neuropsychological tests for PWE. The review revealed a close relationship between self-reported cognitive functioning and the experience of psychological distress.

4.1. Objective attention and executive functioning and self-reported cognitive functioning

Eight of the eleven studies concluded that there was no significant relationship between objective attention and executive functioning and self-reported cognitive functioning [7, 28-31, 35-37]. Two studies found a significant relationship [32, 33] and one found mixed results dependent upon objective measure [34].

The findings of this review appear to support the lack of an association between objective and self-report measures as found in previous studies examining overall cognitive functioning [24] and a previous review of objective and subjective memory reports [13]. The previous review regarding memory found the lack of association to reflect PWE under-estimating their abilities. Within this review, directionality was reported by only two studies. Both showed that participants tended to over-estimate their attention and executive functioning abilities [7, 29], contradicting previous findings [13, 49]. This may reflect PWE attributing attention

and executive functioning difficulties to other domains of cognitive functioning, such as memory.

A slightly higher proportion of studies within this review found a lack of a subjective-objective relationship when compared to the previous review regarding memory [13]. This may be due to a different domain of cognitive functioning being examined, for example it may be more challenging for PWE to discern their abilities within attention and executive functioning as compared to memory. Alternatively, as most studies within this review used self-reports of global cognitive functioning, rather than asking about attention and executive functioning specifically, these self-report measures may not solely represent PWE's perceptions of their attention and executive functioning abilities. This may, therefore, have led studies within this review to find a lack of association between objective and self-report measures. Overall, however, the results of the current review establish further support for the finding of a lack of a subjective-objective relationship and extend it to the domains of executive functioning and attention.

Studies researching the cognitive functioning of people with epilepsy are often limited due to the psychometric properties of neuropsychological tests being used with PWE being unknown. The most common neuropsychological test used by the studies within this review to measure attention and executive function was the EpiTrack [7, 32-34, 37]. This is a test developed purposefully for people with epilepsy as a screening measure of attention and executive functioning. Of the five studies using the EpiTrack, one found no statistically significant subjective-objective relationship [7] and three studies found a statistically significant relationship between objective attention and executive functioning and self-report measures: the only studies within the review which found a relationship [32-34]. The last

study found objective and self-report measures correlated only for participants with attention and executive functioning deficits [37]. Therefore, there may be some preliminary indications that studies using the EpiTrack are more likely to find a relationship with self-report measures than other neuropsychological tests have shown. Of the studies using other neuropsychological tests, two created a composite score of objective attention and executive functioning [28, 29]. This may help to address the limitations to validity of using single tests as a representation of attention and executive functioning abilities, which potentially impacted upon four studies using single measures [30, 31, 35, 36]. In using psychometric tests, there have been additional queries regarding whether neuropsychological measures can be called 'objective' as they may lack ecological validity and applicability to everyday life, a potential limitation to these studies [50]. Difficulties with measurement of self-report and objective functioning have ramifications for clinicians working with PWE. The findings of this study indicate that perceptions of cognitive functioning are complex, and that the subjective-objective discrepancy found for those with higher levels of psychological distress and/or repetitive negative thinking does not necessarily always indicate inaccuracy in reporting. Lack of ecological validity of neuropsychological testing or systemic variables impacting upon self-reporting of cognitive abilities, such as high cognitive demands of a job causing heightened worries of cognitive limitations, are factors which may cause a greater subjective-objective discrepancy. Therefore, the findings of this study, rather than suggesting PWE experiencing psychological distress will subsequently over-estimate their cognitive difficulties, indicate the importance of the clinician retaining awareness of the complex interaction between distress, self-reporting and objective cognitive functioning in developing a formulation.

Using caution in generalising findings from these studies to the general population of PWE is recommended as, when compared to control groups or normative data, four of the studies

reported a substantial proportion of their participant group to experience impaired or below average attention and executive functioning, as determined by objective measures [7, 32, 33, 37]. Descriptions of cognitive functioning were not reported in six studies, therefore it is unknown whether these studies also experienced this potential bias [28-30, 34-36].

As only two studies reported a sample size calculation [36, 37] it is unclear whether sufficient participants were recruited into the studies to permit them to precisely estimate the relationships under question. Although a difficulty often inherent in research recruiting a clinical population, reporting a sample size calculation would have aided in reviewing which studies were equipped with adequate power to measure the relationships between variables and minimise the likelihood of a Type II error occurring. As eight studies made high numbers of comparisons, due to tests being broken down and subtests used, there may have been an increased chance of Type I error occurring [28, 29, 31, 33-36].

4.2. The role of psychological distress

Previous research suggests that anxiety and depression, being correlated more closely with self-reports of cognitive functioning, may have a role regarding the lack of a subjective-objective association noted with PWE [13]. Nine of the eleven studies examined the relationship between self-reported cognitive functioning and psychological distress, using measures of anxiety and/or depression. Seven studies found a statistically significant relationship between the variables [29, 30, 32-35, 37], one study found a mixed result [28] and the last found no relationship [31]. This strongly supports previous research and suggests that PWE's self-reported cognitive abilities are closely related to levels of psychological distress; more specifically, higher levels of psychological distress were associated with more self-reported difficulties [51]. Only five studies compared objective measures of attention and

executive functioning and psychological distress, showing mixed results [7, 30, 32, 35, 36]. It is not felt, therefore, that a sufficiently coherent answer was given as to the nature of this relationship. Although self-reported cognitive functioning and psychological distress have been shown to be closely related more often than self-reports and objective measures, no studies within the review examined whether psychological distress impacts upon the relationship between objective measures and self-reports.

This systematic review excluded studies with participants who had undergone epilepsy surgery to minimise this impacting upon results. There still appeared, however, to be a recruitment bias, with nine studies using hospitals and outpatient clinics [7, 29, 31-37]. This potentially limits the generalisability of the findings of this review, as PWE who are seizure free or have infrequent seizures due to treatment such as AEDs are less likely to attend regular outpatient clinics [52]. Additionally, PWE experiencing more frequent seizures are at an increased likelihood of experiencing psychological distress [53], which may influence results. As psychological distress was not compared to the norm in ten of the eleven studies, it is unknown whether the participants experienced significantly more distress than a normative sample [7, 28-30, 32-37].

4.3. Limitations of this review

Limitations of the methodology used within this review include that using search terms which discounted 'Child' and 'Juvenile' may have discounted studies regarding juvenile myoclonic epilepsy, which could have been using adult participants with epilepsy originating during childhood. A conceptual issue which may be a limitation of this review is that attention and executive functioning are two domains of cognition which have been combined within this review. Although they have significant overlap and commonalities, this may affect

findings, should there be differences in PWE's perception and reporting of their attention compared to their executive functioning abilities.

The concept of executive functioning is a broad term and covers skills such as planning and organising, attention, working memory, inhibition, self-regulation, self-monitoring and initiation. Due to the breadth of cognitive skills which the term executive functioning encompasses, an in-depth and detailed neuropsychological assessment is often undertaken to assess these abilities. Unfortunately, one of the limitations of the literature outlined within this systematic review, is the focus of studies assessing executive functioning by assessing the areas of attention and processing, rather than considering planning, problem solving and reasoning. Therefore, the applicability of the findings of this review to all areas of executive functioning has limitations.

4.4. Future implications

The results of this systematic review support findings of a lack of association between objective and self-report measures of cognitive functioning in PWE and further this to the domains of attention and executive functioning. Additionally, the review suggests that self-reports of cognitive functioning are closely associated with psychological distress. A question which the review has not been able to answer is whether these two associations are related or impact upon one another. Future research could increase understanding in this area by considering whether psychological distress affects the relationship between objective and self-reported cognitive functioning, and the role of any associated processes or mechanisms.

This review further supports the importance of early detection of cognitive difficulties for PWE. Self-reported cognitive difficulty may indicate the need for neuropsychological cognitive support strategies, however, the results of this review suggest it may also be an indication of

psychological distress. Interventions targeting psychological distress may reduce the discrepancy self-report scores have with objective results.

Due to methodological limitations, it cannot be discounted that the findings of this review are due to an artefact of methodology. For example, the application of objective and self-report measures which have not had their psychometric properties assessed with PWE may impact upon validity and reliability to an unknown extent. Further research into the psychometric properties of neuropsychological measures with PWE could help further strengthen research with this population and support clinical practice.

4.5. Conclusions

This systematic review has shown that objective measures of attention and executive functioning often do not represent the cognitive abilities that PWE perceive themselves to have. The experience of psychological distress appears more closely related to PWE's self-reported cognitive functioning. However, there are significant methodological limitations within the research reviewed which prompt caution in interpreting these results. Clinicians working with PWE should be aware that psychological distress and self-perceived cognitive deficits appear to be significantly related and decreasing this discrepancy might increase many areas of quality of life for PWE. In assessing objective attention and executive functioning, measures of mood and self-reports should be included to develop a comprehensive neuropsychological formulation.

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Chapter 2: The relationship between objective cognitive ability and subjective cognitive ability and the moderating role of attentional control and repetitive negative thinking in people with epilepsy

For submission to Epilepsy and Behavior, author guidelines found in Appendix A

Abstract

Objective: The self-reported cognitive abilities of people with epilepsy, often do not reflect the results of neuropsychological assessment, but are instead highly associated with psychological distress. The influence of psychological distress upon the relationship between objective and self-reported cognitive functioning remains undetermined. This study, therefore, aims to understand the role of psychological distress upon the subjective-objective cognitive functioning relationship and the psychological processes, associated with anxiety and depression, which may also be implicated. Heightened levels of repetitive negative thinking and low attentional control are psychological processes closely associated with psychological distress, which may offer further understanding of the mechanisms influencing self-reported cognitive difficulties from people with epilepsy.

Method: Thirty-seven adults (ages 18-61) with epilepsy were recruited from outpatient clinics and epilepsy support groups in North-West England. Objective cognitive functioning was assessed using a battery of neuropsychological tests assessing long- and short-term memory, attention, executive functioning, processing speed and verbal fluency (subtests of the Wechsler Adult Intelligence Scale-Fourth Edition, Delis-Kaplan Executive Function System and the California Verbal Learning Test-Second Edition). Participants completed self-report questionnaires regarding cognitive functioning (Perceived Deficits Questionnaire), anxiety (General Anxiety Disorder Assessment), depression (Patient Health Questionnaire), attentional control (Attentional Control Scale) and repetitive negative thinking (Perseverative Thinking Questionnaire). Moderation and correlational analyses were used.

Results: Lowest objective neuropsychological test scores were found in domains of short- and long-term memory, although participants subjectively rated their attention and

concentration as most problematic. 41% of participants reported moderate to severe anxiety and/or depression. Objective and self-reported cognitive functioning were found to be moderately correlated (*r*=0.69). Psychological distress and repetitive negative thinking significantly moderated the relationship between objective and self-reported cognitive functioning, accounting for 66% and 62% respectively of the variance in self-reported cognitive functioning. Attentional control did not significantly moderate the relationship.

Conclusion: Participants with low or average levels of psychological distress and/or repetitive negative thinking had self-reported cognitive functioning scores which were significantly related to their results from objective testing. However, for those with high levels of psychological distress and/or repetitive negative thinking, there was a lack of association between results on self-report measures and objective cognitive functioning. Targeting psychological distress and repetitive negative thinking may help in reducing perceptions of cognitive deficit for people with epilepsy who under-estimate their abilities.

Keywords

Epilepsy, self-report, cognitive functioning, attentional control, repetitive negative thinking, psychological distress.

1. Introduction

1.1. Epilepsy and cognitive functioning

Epilepsy is a condition which can have a broad impact upon the lives of people with epilepsy (PWE) psychologically, cognitively, behaviourally and socially [1]. Research highlights that PWE are significantly more likely to experience cognitive impairment in areas of memory, attention, concentration, language and intellect [2]. Attention and executive functioning impairments have been demonstrated in 49.4% of newly diagnosed PWE and memory difficulties have been shown in 47.8% [3]. Variables potentially impacting upon PWE's cognitive functioning include length of epilepsy duration [4], seizure severity [5], neuropathology, such as the nature of the lesion, and also the use of anti-epileptic medication (AEDs), which can affect areas of the brain required for learning and memory [6]. However, with regard to PWE's subjective reports of their cognitive functioning, some studies have shown there to be little impact from these epilepsy-related factors [5] and suggest that psychosocial factors may be important considerations in understanding the cognitive experiences of PWE [6].

1.2. Self-reported cognitive functioning

Within clinical practice, clinicians often rely upon the patient's self-report of cognitive difficulties as an initial indication for further investigation through neuropsychological assessment. Self-reporting relies upon an individual being able to accurately perceive and report their cognitive abilities. However, research suggests that there can be a notable discrepancy between results of objective assessment and self-reports [7-9] as some studies have shown that PWE under-estimate their cognitive abilities [10] and others have shown they over-estimate their cognitive abilities [11]. This discrepancy may be important to note

for the clinician as, for the individual with epilepsy, perceiving oneself to have cognitive deficits can be detrimental to multiple aspects of their lives, including relationships, stigma, employment and education [12]. Therefore, reducing any discrepancy between objective and self-reported cognitive functioning for PWE may increase quality of life. So far it is unclear what may be causing this subjective-objective discrepancy for PWE. However, family-reports of the person with epilepsy's cognitive functioning often show a closer association with objective assessments than PWE's self-reports do [8, 13]. This may implicate individual factors in influencing a subjective-objective discrepancy.

1.3. Psychological distress

PWE are more likely to experience mental health difficulties than the general population, with population-based studies indicating that 19-30% of PWE experience clinically relevant levels of depression and 11% experience anxiety [14]. Self-reports of cognitive functioning in PWE are often more closely correlated with the individual's experience of psychological distress than with their scores from objective cognitive assessment [10, 15, 16]. One study found 42% of the variance in self-reported cognitive ability to be associated with depression, anxiety and neuroticism [8], and PWE experiencing higher levels of depression report significantly more cognitive deficits than those experiencing lower levels of depression [9]. Despite PWE usually attending regular medical appointments reviewing their epilepsy, often they do not receive appropriate support for mental health difficulties, which can go undetected [17].

1.4. Repetitive negative thinking and attentional control

How psychological distress influences self-reported cognitive functioning is unclear. Two cognitive processes, which appear closely related to anxiety and depression in the

general population, are heightened repetitive negative thinking and low levels of attentional control [18]. These processes may influence self-reported cognitive functioning in PWE and, if they do, would offer insights into what interventions may be helpful in reducing subjective-objective discrepancies.

Repetitive negative thinking is a term used to describe ruminative and persistent thoughts an individual has about themselves, their problems or difficulties [19]. Engaging in high levels of repetitive negative thinking is a process common to both depression and anxiety, which frequently co-occur [20], although the content of thoughts may vary [21, 22]. High levels of repetitive negative thinking predict the occurrence of depression and anxiety in individuals with physical long-term conditions, although this has not yet been researched in PWE [23]. Content of repetitive thoughts for those with chronic conditions has been found to be associated with worries regarding the negative effects of the physical condition [24].

Attentional control can be defined as the ability to control and direct concentration and attention to stimuli which may be less salient, over stimuli which may be more accessible [25]. People with temporal lobe epilepsy have been found to have reduced abilities in some aspects of attentional control [26], which has been posited to be due to neurological differences, such as epileptic discharges from temporal lobe regions to the frontal lobes [27]. Low levels of attentional control have been associated with both depression and anxiety [28, 29].

Although repetitive negative thinking and attentional control are distinct processes with separate associations with psychological distress [30] they are processes which are closely associated [31]. The directionality between psychological distress, attentional control and repetitive negative thinking has been debated. Attentional Control Theory states that poor attentional control is shown in individuals experiencing significant levels of psychological

distress, due to attentional resources being used for worry and rumination. This therefore impairs the goal-directed attentional system and increases the influence of the stimulus-driven attentional system, meaning attentional control is reduced [32]. This theory posits that poor attentional control occurs as a consequence of psychological distress, which may be mediated by repetitive negative thinking [30]. However, other theories have suggested that poor attentional control can increase the likelihood of repetitive negative thoughts, which then leads to psychological distress [18, 19].

Both processes can cause an increase in cognitive content being self-evaluative and negative [33], which may apply to perceptions of cognitive functioning for PWE. There are queries, therefore, regarding whether the presence of these transdiagnostic processes may be implicated in PWE evaluating their cognitive abilities negatively, and perceiving themselves to experience more cognitive difficulty than neuropsychological assessment suggests. This may have implications for intervention as, despite directionality being unclear, studies have shown that in the general population psychological distress can be reduced by interventions targeting attentional control [34, 35] and repetitive negative thinking [36].

1.5. Study aims

Reports of cognitive functioning from PWE are often more closely associated with levels of anxiety and depression than with results of objective testing. It is unclear whether the experience of psychological distress may impact upon the relationship between objective and self-reported cognitive functioning. Psychological distress can be accompanied by heightened levels of repetitive negative thinking and low attentional control, which may impact upon the subjective-objective relationship. This cross-sectional study aims to address the hypotheses that:

1. There will be a significant correlation between objective and self-reported cognitive functioning, with more objective cognitive functioning difficulties indicating more self-reported cognitive difficulties.
2. Psychological distress will moderate this relationship through weakening the objective-subjective relationship when higher levels of psychological distress are present.
3. Attentional control will act as a moderator through increased levels of attentional control strengthening the relationship between objective and self-reported cognitive functioning.
4. Repetitive negative thinking will moderate the relationship between objective and self-reported cognitive functioning, through higher levels of repetitive negative thinking weakening the objective-subjective relationship.

2. Methods

2.1. Participants

A cross-sectional study was undertaken with individuals with an established diagnosis of epilepsy. Participants were recruited between April 2016 and January 2017 from outpatient clinic appointments at a hospital offering tertiary neurology services in North-West England and from epilepsy support groups in North-West England. Participants were all aged eighteen or over. To participate they had to be able to give informed consent and understand English sufficiently to complete questionnaires alone and undertake psychometric assessment. Potential participants were excluded if they experienced another neurological condition which might also contribute to cognitive impairment (e.g. dementia or brain injury).

2.2. Procedure

Ethical approval for the study was gained from the North West-Lancaster Research Ethics Committee (Appendix F). All participants were given an information sheet (Appendix G) and gave written, informed consent prior to taking part (Appendix H). Participants who consented to take part completed a battery of neuropsychological tests assessing objective cognitive functioning and then went on to complete questionnaires assessing quality of life, anxiety, depression, self-reported cognitive functioning, attentional control and repetitive negative thinking. The testing took between 45-60 minutes within participants' homes, community and hospital settings.

2.2.1. Objective cognitive functioning assessment

A battery of neuropsychological tests were completed by participants. The tests were selected after a literature review regarding domains of cognitive functioning which PWE

typically experience the most difficulties in, which were memory, attention and concentration, language and processing speed [37]. The measures assessed:

- Learning, short- and long-term verbal memory: California Verbal Learning Test- Second Edition (CVLT-II) [38]. This measure shows good test-retest reliability (*r*=0.80-0.84) [39]. Although the validity of this measure, when assessed with PWE, shows some overlap with language, attention and vocabulary, it is still considered to have adequate construct validity of learning and long-term memory with PWE, explaining 18% and 13% of variance respectively in a principle component analysis [40].
- Concentration and working memory: Wechsler Adult Intelligence Scale- Fourth Edition (WAIS-IV) [41] Digit Span and Arithmetic subtests. The WAIS-IV has high correlations with measures of overall intelligence (*r*=0.88) and specific aspects of cognitive functioning and has good test-retest reliability in the general population [41]. Although used widely with PWE, it has received relatively limited attention in terms of assessing its reliability and validity.
- Processing speed: WAIS-IV Symbol Search and Coding subtests. Again, the WAIS-IV is used widely with PWE in clinical settings. Children with epilepsy have been found to do significantly worse on the Digit Span, Coding and Symbol Search subtests of the WISC-IV than a control group [42].
- Verbal fluency and executive functioning: Delis-Kaplan Executive Function System (D-KEFS) [43] Verbal Fluency and Trails subtests. The psychometric properties of the D-KEFS and other measures of executive functioning do not appear to have been evaluated with PWE. However the D-KEFS Trails subtest has been found to have sensitivity to the type of epilepsy, with individuals with frontal lobe epilepsy significantly impaired compared

to a control group and participants with temporal lobe epilepsy [44]. Children with epilepsy show significantly lower scores than the general population on the D-KEFS [45]. As a test which is used extensively in clinical settings, the D-KEFS was therefore felt to be a tool which could detect executive functioning abilities sufficiently.

2.2.2. Self-reported cognitive functioning

The Perceived Deficits Questionnaire [46] was used to assess self-reported cognitive functioning (Appendix I). It was originally developed for use with people with multiple sclerosis. It is a 20-item, self-report assessment of cognitive functioning. Participants are presented with statements and asked to rate how often the statement has applied to them in the past four weeks using a five-point Likert scale from 0='Never' to 5='Almost always'. The cognitive domains comprising the questionnaire are: prospective memory (e.g., 'Forget what you came into the room for'), retrospective memory (e.g., 'Forget if you had already done something?'), attention (e.g., 'Have trouble concentrating on what people are saying during a conversation') and planning and organisation (e.g., 'Have trouble getting things organised'), although these domains correlate highly with each other. The combined subscales give a score ranging from 0 to 80, with higher scores indicating more perceived cognitive impairment. The measure was chosen as it assesses multiple areas of cognitive functioning and these domains map closely to those assessed by the objective assessments.

Due to the Perceived Deficits Questionnaire not yet being established in the field of epilepsy, the reliability of the measure was assessed using split-half reliability analysis of Cronbach's alpha, which indicated good internal reliability (α=0.92). The measure has been used with other populations and the internal consistency of the measure was also found to be good in individuals with whip-lash (Rasch-generated reliability >0.8) [47] and individuals with depression (α=0.81-0.96) [48].

2.2.3. Attentional control and repetitive negative thinking

The Attentional Control Scale [32] was used to assess aspects of attentional control and is a 20-item, self-report questionnaire (Appendix I). It asks participants to rate on a four-point Likert scale how much they 'generally' agree that the statements apply to them from 1='Almost never' to 4='Always'. An example of a statement within the Attentional Control Scale is 'I can quickly switch from one task to another'. Higher scores denote less difficulty with attentional control. There has been evidence for the scale's internal and construct validity (α=0.88) [49] and internal consistency (α=0.84) in students not experiencing epilepsy [50].

Repetitive negative thinking was measured using the Perseverative Thinking Questionnaire [51] (Appendix I). It is a self-rated, 15-item questionnaire. It asks how often participants 'typically' engage in different examples of repetitive thinking which they find difficult to disengage from. The response scale ranges from 0='Never' to 4='Almost always'. An example of a statement is 'Thoughts intrude into my mind'. Higher scores denote higher levels of repetitive negative thinking. It has been found to have good levels of convergent validity with other measures of repetitive thinking (r=0.62-0.72) and internal consistency (α=0.94-0.95) in both a non-clinical sample and in a sample of people with a diagnosis of a mental health difficulty of some kind e.g. anxiety, eating disorders or depression [51].

2.2.4. Psychological distress

Anxiety was assessed using the Generalised Anxiety Disorder Assessment (GAD-7) [52], which is a short screening tool comprised of seven questions (Appendix I). It asks individuals to rate how frequently they noticed particular symptoms of anxiety over the previous two weeks. The total score is out of 21 with scores of 5, 10, and 15 as the cut-off

points for ‘mild’, ‘moderate’ and ‘severe’ anxiety respectively. The GAD-7 has a sensitivity of 89% when using the highest possible score as the threshold score [52]. The measure has been validated with people with epilepsy in French [53], Korean [54] and Chinese [55] although not in English.

Depression was assessed using the Patient Health Questionnaire (PHQ-9) [56]; a self-report screening measure for depression which comprises nine questions asking individuals to rate how often they experienced different symptoms of depression over the past two weeks (Appendix I). Scores are out of a total of 27 and scores of 5, 10, 15 and 20 are taken as the cut-off points for ‘mild’, ‘moderate’, ‘moderately severe’ and ‘severe’ depression respectively. The PHQ-9 has 61% sensitivity and 94% specificity to depression [57] and has been found to have good validity for PWE [58].

2.2.5. Clinical variables

Data were collected on AEDs which participants were taking and for how long they had been diagnosed with epilepsy. To allow the recruited sample to be further described and compared to a normed sample of PWE, perceived quality of life was assessed using the Quality of Life in Epilepsy Inventory (QOLIE-31) [59] (Appendix I). This is a 31-item self-report health-related quality-of-life questionnaire specific to PWE. The QOLIE-31 asks participants questions covering general and epilepsy-specific domains of wellbeing over the past four weeks. Lower scores denote a better quality of life state. Internal consistency reliability coefficients (α=0.77-0.85) and test-retest data demonstrated good reliability (r=0.64-0.85). Comparison QOLIE-31 data from a normative sample of PWE recruited from epilepsy clinics in the US and described as not experiencing any physical or mental health problems, have been collected [59].

2.3. Statistics

2.3.1. Sample size

The required sample size was estimated using G*Power [60]. In the context of an exploratory study, and as no studies appear to have undertaken a moderation analysis regarding a similar research question, a conservative medium effect size was decided upon with three main predictors and the alpha level set to 0.5. A sample size of 77 was required based on these parameters.

2.3.2. Analysis

Analyses were conducted using IBM SPSS Statistics (2015). Descriptive statistics were gathered on the means, ranges and standard deviations for participant ages, time since diagnosis, scores on the Attentional Control Scale, Perseverative Thinking Questionnaire, objective cognitive functioning tests and subtests of the Perceived Deficits Questionnaire. Means were computed for QOLIE-31 domains.

Raw scores on the tests of objective cognitive functioning (assessing processing speed, working memory, long-term memory, short-term memory, executive functioning and verbal fluency) were converted to t-scores. The potential range of t-scores is 10-90 with 'average' being 50 (SD=10) and higher scores indicating better cognitive functioning in that area. A principle component analysis was performed to reduce the data assessing aspects of objective cognitive functioning into a composite score. Additionally, as it could not automatically be assumed that averaging a participant's score data would provide a reliable and valid measure of their objective cognitive functioning, a principle component analysis served to capture the data of the objective measures more accurately. A principle component analysis was also conducted on the depression and anxiety measures, to explore whether it

was possible to reduce the two variables into a composite score representing psychological distress.

The relationship between objective and self-reported cognitive functioning was assessed using Pearson's correlation analysis. A correlational matrix using Pearson's r was conducted to assess the correlations between attentional control, repetitive negative thinking and psychological distress. Moderation analysis using PROCESS [61] was conducted to assess the individual moderating roles of the variables attentional control, repetitive negative thinking and psychological distress within the relationship between objective and self-reported cognitive functioning. Significance was set at an alpha level of 0.05. P-plots, residual scatterplots and histograms were used to assess for linearity, normality and homoscedasticity. Directionalities of the measures used are shown in Table 1.

Table 1. Directionality of measures

Measure	**Direction**
Objective cognitive functioning	Higher scores = Better cognitive functioning
Perseverative Thinking Questionnaire	Higher scores = More repetitive negative thinking
Attentional Control Scale	Higher scores = Better attentional control
Psychological Distress measures	Higher scores = More anxiety/depression symptoms
Quality of Life in Epilepsy Questionnaire	Higher scores = Worse quality of life
Perceived Deficits Questionnaire	Higher scores = More perceived cognitive impairment

3. Results

3.1. Participants

3.1.1. Demographics

A total of 39 participants were recruited through epilepsy clinics (n=23) and support groups (n=16). 37 completed all measures (14 male, 23 female) (Appendix J) (Table 2); one participant dropped out due to time pressure and the other due to a family commitment.

When comparing participants' mean scores on the domains of quality of life as measured by the QOLIE-31 (i.e. Seizure Worry, Quality of Life, Emotional Wellbeing, Energy/ Fatigue, Cognitive Functioning, Medication Effects, Social Functioning, Overall Score) with a normative sample of PWE, the recruited sample reported poorer quality in all areas except Seizure Worry [59].

Table 2: Demographic and clinical characteristics of the recruited sample

Demographic variable	**Participant data**	**Norms** [59]
Age (years)	Range: 18-61	
	Mean: 42.5	
Sex	Standard deviation: 11.5	
Years since diagnosis of epilepsy	Male: 14 (38%)	
	Female: 23 (62%)	
	Range: 0.5-56	
	Mean: 21.1 years	
	Standard deviation: 13.4	
Medication	Monotherapy: 23 (62.2%)	
	Polytherapy: 14 (37.8%)	

Demographic variable	**Participant data**	**Norms** [59]
Patient Health Questionnaire (PHQ-9)	Mild, n=11 (30%)	
	Moderate, n=9 (24%)	
	Moderately Severe, n=3 (8%)	
	Severe, n=4 (11%)	
Generalised Anxiety Disorder Assessment (GAD-7)	Mild, n=13 (35%)	
	Moderate, n=3 (8%)	
	Severe, n=6 (16%)	
Quality of Life in Epilepsy (QOLIE-31) sub-scales mean scores	Seizure Worry: 63.5	58.3
	Quality of Life: 61.5	67.2
	Emotional Wellbeing: 60.1	67.2
	Energy/ Fatigue: 43.4	55.3
	Cognitive Functioning: 49.9	60
	Medication Effects: 51.8	55.3
	Social Functioning: 62.4	67.3
Overall QOLIE-31 mean score	56.2	62.9

Note: QOLIE-31: Higher scores on the QOLIE-31 subscales indicate lower quality of life and the scores range from 0-100.

3.1.2. Psychological distress

The GAD-7 indicated that 24% of the sample reported moderate or severe anxiety and the PHQ-9 indicated that 38% experienced moderate, moderately severe or severe depression. Across both measures, 41% demonstrated moderate or severe anxiety and/or depression.

A principle component analysis conducted on the raw scores of the GAD-7 and PHQ-9 indicated that 88.68% of the variance was explained by one factor with an eigenvalue above 1. The scree plot showed inflexions which supported this and, as the two variables loaded

onto one factor, no rotation was performed upon the data (Appendix K). Consequently, a psychological distress composite score was generated using the two factors depression and anxiety.

3.1.3. Objective cognitive functioning

The raw scores of the objective cognitive tests were converted into age-corrected t-scores and descriptive statistics were generated (Table 3). The principle component analysis obtained eigenvalues for each factor in the data and revealed one factor with an eigenvalue above 1 and which explained 62% of the variance. The scree plot showed inflexions which supported this (Appendix L). No rotation was therefore necessary. Due to all variables loading onto one factor, the objective cognitive functioning composite could be generated using one factor to represent the six objective cognitive functioning variables. Although 38% of the variance was lost, a decision was made to use one factor to represent objective cognitive functioning due to the potential for family-wise error when using multiple factors.

The principle component analysis indicated, through the Kaiser-Meyer-Olkin measure, that the sample size was adequate for the analysis (KMO=0.816), described as a 'meritorious' size [62]. Each individual variable had a Kaiser-Meyer-Olkin value higher than 0.738, which is above the suggested limit of 0.5 [63].

3.1.4. Subjective cognitive functioning

The subtest of the Perceived Deficits Questionnaires with the highest mean score was Attention/Concentration indicating that, on average, participants perceived most deficit within this area. Prospective Memory had the lowest mean score, indicating it was the area of least perceived difficulty (Table 4).

Table 3: Age corrected scores for objective cognitive functioning domains

Objective cognitive functioning domain	**Range**	**Mean**	**Standard deviation**	**Percentage more than 1 standard deviation below the mean**
Working Memory	21.5-72.5	45.5	12.3	38%
Processing Speed	20-65	43.1	11.4	27%
Long-term Memory	10-56.6	37.4	12.3	49%
Short-term Memory	10-62.5	38.4	12.3	49%
Executive Functioning	20-79	45.4	13.7	24%
Verbal Fluency	20-75	46.9	13.8	30%

Note: The potential range of t-scores is 10-90 with 40-60 indicating average. Higher scores indicate better levels of cognitive functioning in that area.

Table 4: Descriptive statistics for the Perceived Deficits Questionnaire

Subtest	**Mean and standard deviation**	**Range**
Attention/ Concentration	12.14 (3.66)	3-19
Retrospective Memory	11.17 (4.54)	2-18
Prospective Memory	8.66 (4.12)	2-17
Planning/ Organisation	10.2 (4.11)	3-19
Overall Score	41.86 (14.54)	13-72

Note: Higher scores indicate more perceived deficit. Each subtest is scored out of 20.

3.1.5. Attentional control and repetitive negative thinking

The mean score for the Attentional Control Scale was found to be 46.97 (SD=10.52), range: 25-69. The mean score for the Perseverative Thinking Questionnaire was 28.11 (SD=14.36), range: 4-58.

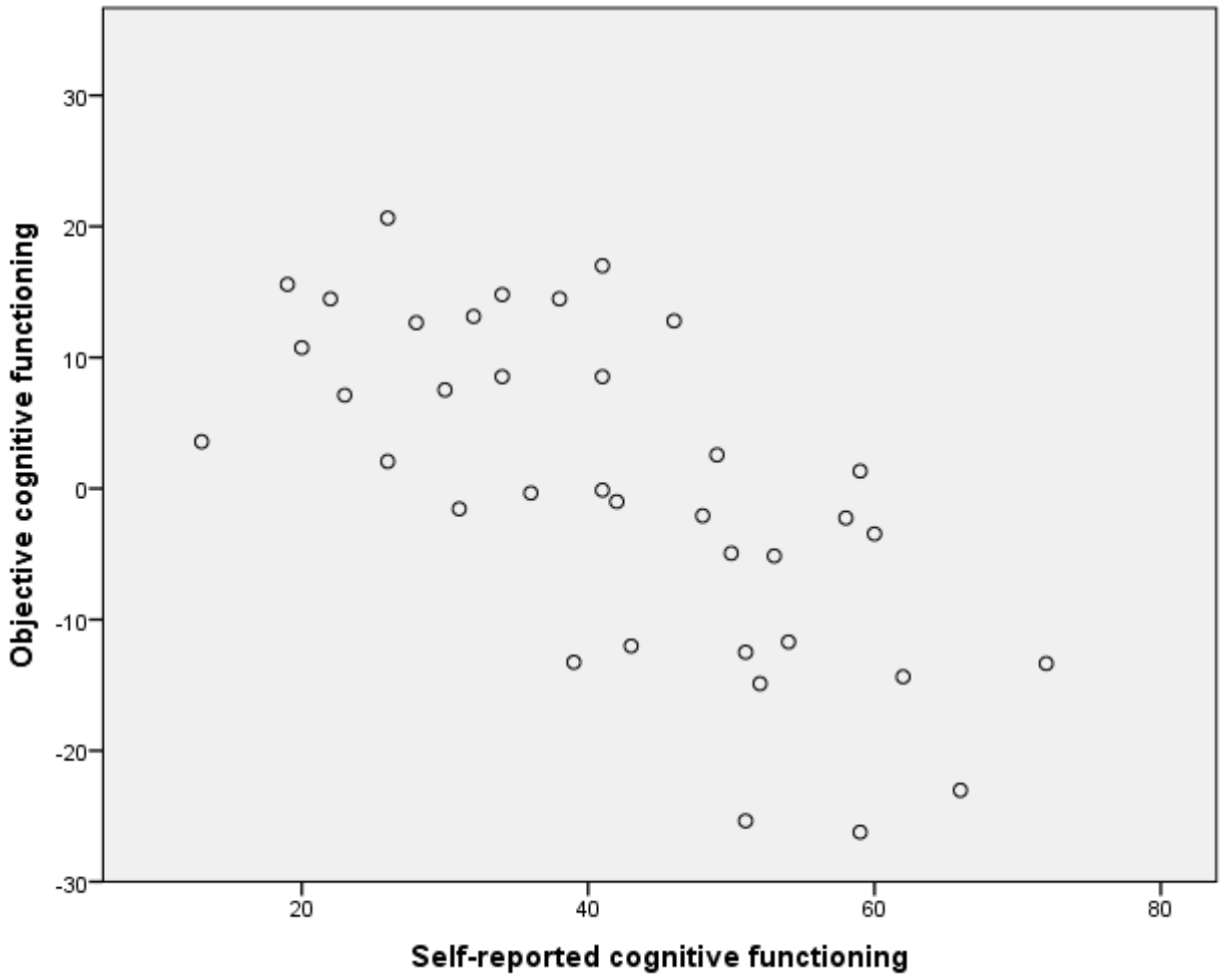
3.1.6. Relationship between psychological distress, repetitive negative thinking and attentional control

P-plots assessing the linearity and normality for these three variables showed that the assumptions were met and no bias was observed. A Pearson's correlational matrix confirmed the assumed relationship between the three factors: psychological distress and repetitive negative thinking r=.57, p<.01; psychological distress and attentional control r=-.52, p<.01; and attentional control and repetitive negative thinking r=.54, p<.01 (Appendix M). Scatterplots showing these relationships are shown in Appendix N.

3.2. Relationship between objective and self-reported cognitive functioning

A Pearson's correlation analysis showed a statistically significant correlation between objective and self-reported cognitive functioning (r=-0.69, p<.01) (Appendix O). The direction of this correlation indicated that increased deficits in objective cognitive functioning were associated with increased self-reported cognitive deficits by the individual (Figure 1).

Figure 1: Scatterplot showing the relationship between self-reported cognitive functioning and objective cognitive functioning



3.3. Psychological distress as a potential moderator between objective and self-reported cognitive functioning

P-plots, residual scatterplots and histograms, assessing for linearity, normality and homoscedasticity, using psychological distress as the dependent variable, found psychological distress showed some heteroscedasticity. This was corrected for within the moderation analysis.

A moderation analysis, using objective cognitive functioning as the predictor variable, self-reports as the outcome variable and psychological distress as the potential moderator,

found 66% of the variance in self-reported cognitive functioning was accounted for by these two variables and their interaction ($F(3,33)=18.44$, $p<0.001$, $R^2=0.66$) (Appendix P).

The effect of psychological distress ($b=6.27$, $t(33)=3.49$, $p=0.00$) and objective cognitive functioning ($b=-0.67$, $t(33)=-5.27$, $p=0.00$) on self-reported cognitive functioning were both found to be statistically significant. The effect of the interaction on self-reported cognitive functioning was statistically significant ($b= 0.35$, $t(33)=2.52$, $p=0.02$) (Table 5).

Table 5: Linear model of predictors of self-reported cognitive functioning

	b	***SE B***	***t***	***P***
Constant	43.29	1.53	28.26	$p<.01$
Psychological distress	6.27	1.80	3.49	$p<.01$
Objective cognitive functioning	-0.67	0.12	-5.27	$p<.01$
Psychological distress x objective cognitive functioning	0.35	0.14	2.52	$p<.05$

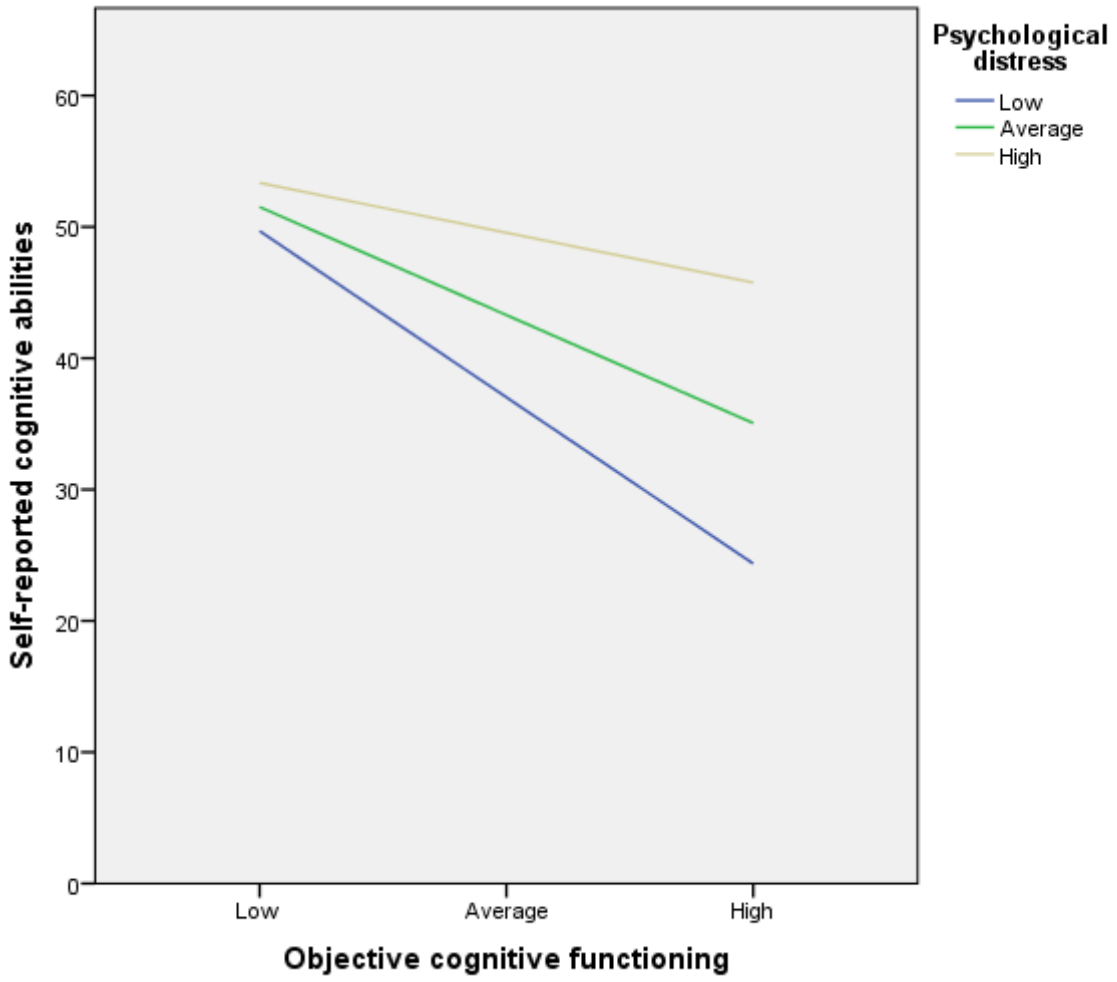
The effect of objective cognitive functioning predicting self-reported cognitive functioning varied at each level of psychological distress (Table 6). A statistically significant relationship between objective and self-reported cognitive functioning for participants experiencing low levels of psychological distress ($b=-1.01$, $t(33)=-4.74$, $p=0.00$) and average levels of psychological distress ($b=-0.66$, $t(33)=-5.27$, $p=0.00$) was found. However, there was no statistically significant relationship between objective and self-reported cognitive functioning for participants experiencing high levels of psychological distress ($b=-0.30$, $t(33)=-1.93$, $p=0.06$).

Table 6: Conditional effect of objective cognitive functioning on self-reported cognitive functioning at values of psychological distress

Psychological Distress	***b***	***SE B***	***t***	***p***
-1.00	-1.01	0.21	-4.74	*p*<.01
0.00	-0.66	0.12	-5.27	*p*<.01
1.00	-0.30	0.16	-1.93	*p*>.05

The Johnson-Neyman technique showed the amount of data outside the zone of significance accounted for 21.6% of the data (*b*=-0.31, *t(*33)=-2.03*, p*=0.05). As psychological distress lowered, the relationship between objective scores and self-reports increased to the best score of the psychological distress composite (*b*=-1.15, *t*(33)=-4.40, *p*=0.00).

Figure 2: Simple slopes equations of the regression of self-reported cognitive functioning on objective cognitive functioning at three levels of psychological distress



3.4. Attentional control as a potential moderator between objective and self-reported cognitive functioning

P-plots, residual scatterplots and histograms assessing linearity, normality and homoscedasticity showed that the assumptions were met and no bias was observed. A model, using objective cognitive functioning as the predictor variable, attentional control as the potential moderator and self-reported cognitive functioning as the dependent variable ($F(3,33)=20.14$, $p<0.001$, $R^2=0.63$), showed that 63% of the variance of self-reported cognitive functioning was due to these two variables and their interaction (Appendix Q).

The effect of attentional control (*b*=-0.58, *t(*33)=-2.32, *p*=0.03) and objective cognitive functioning *(b*=-0.59, *t(*33)=-4.39, *p*=0.00) on self-reported cognitive functioning was statistically significant. However, the interaction of attentional control and objective cognitive functioning on self-reported cognitive functioning was not statistically significant (*b*=-0.01, *t(*33)=-0.22, *p*=0.82) (Table 7).

Table 7: Linear model of predictors of self-reported cognitive functioning

	B	***SE B***	***t***	***p***
Constant	42.14	2.01	21.01	p < .01
Attentional control	-0.58	0.25	-2.32	p < .05
Objective cognitive functioning	-0.59	0.13	-4.39	p < .01
Attentional control x objective cognitive functioning	-0.01	0.02	-0.22	p > .05

3.5. Repetitive negative thinking as a potential moderator between objective and self-reported cognitive functioning

P-plots, residual scatterplots and histograms assessing linearity, normality and homoscedasticity showed the assumptions were met. A moderation analysis using objective cognitive functioning as the predictor variable, self-reported cognitive functioning as the outcome variable and repetitive negative thinking as a potential moderator (*F*(3,33)= 16.81, *p*<0.001, R^2=0.62) showed that 62% of the variance of self-reported cognitive functioning was due to objective cognitive functioning and repetitive negative thinking and their interaction (Appendix R).

The effect of repetitive negative thinking (*b*=0.38, *t(*33)=3.12, *p*=0.00) and objective cognitive functioning *(b*=-0.77*, t(*33)=-5.56, *p*=0.00) and their interaction (*b*=0.02*, t(*33)=2.05, *p*=0.048) on self-reported cognitive functioning was statistically significant (Table 8).

Table 8: Linear model of predictors of self-reported cognitive functioning

	B	***SE B***	***t***	***p***
Constant	41.60	1.64	25.43	p < .01
Repetitive negative thinking	0.38	0.12	3.12	p < .01
Objective cognitive functioning	-0.77	0.14	-5.56	p < .01
Repetitive negative thinking x objective cognitive functioning	0.02	0.01	2.05	p < .05

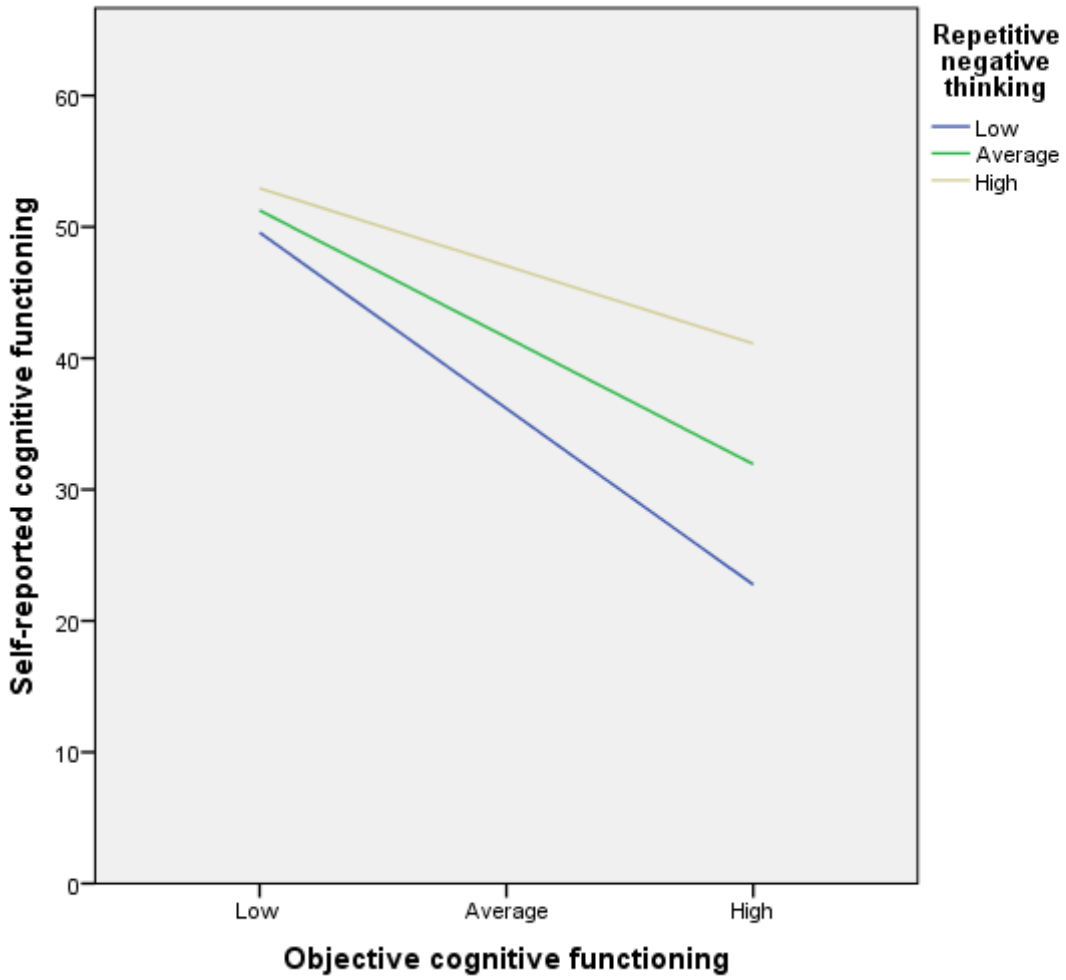
The effect of objective cognitive functioning predicting self-reported cognitive functioning varied at each level of perseverative thinking (Table 9). For participants who experienced low levels (*b*=-1.07, *t*(33)=-6.62, *p*=0.00) and average levels (*b*=-0.77, *t*(33)=-5.56, *p*=0.00) of repetitive negative thinking, objective cognitive functioning and self-reported cognitive functioning had a statistically significant relationship. However, for those experiencing high levels of repetitive negative thinking, there was no statistically significant relationship between objective and self-reported cognitive functioning (*b*=-0.47, *t*(33)=-2.02, *p*=0.052).

The Johnson-Neyman technique found the zone of significance accounted for 83.8% of the data. As levels of repetitive negative thinking lowered, the relationship between objective and self-reported cognitive functioning increased to the best score on repetitive negative thinking (*b*=-1.27, *t*(33)=-5.43*, p*=0.00).

Table 9: Conditional effect of objective cognitive functioning on self-reported cognitive functioning at values of repetitive negative thinking

Repetitive negative thinking	***b***	***SE B***	***t***	***p***
-14.36	-1.07	0.16	-6.62	*p*<.01
0.00	-0.77	0.14	-5.56	*p*<.01
14.36	-0.47	0.23	-2.02	*p*>.05

Figure 3: Simple slopes equations of the regression of self-reported cognitive functioning on objective cognitive functioning at three levels of repetitive negative thinking



4. Discussion

4.1. Objective and self-reported cognitive functioning

Contrary to most previous studies, which found that PWE's perceptions of their cognitive abilities often do not reflect results of neuropsychological testing [10, 64, 65], this study found participants' reports of their cognitive abilities to be broadly associated with the results of neuropsychological tests, deemed objective measures. The reason for this study finding a correlation is unclear. The finding may have been influenced by the self-report measure used. Self-report measures have varied widely in previous studies investigating self-reported cognitive functioning in PWE. This study employed the Perceived Deficits Questionnaire, the use of which is in its infancy with PWE. It was found to have good internal consistency and it may be a tool which is able to elicit reports of cognitive abilities from PWE which bear a close association with objective measures.

The close subjective-objective relationship may also have been influenced by participants completing the self-report measure directly after completing the objective cognitive assessment. Although ordered this way to minimise fatigue before objective cognitive testing, the ordering could have enhanced a subjective-objective relationship through priming participants to their abilities. It not clear in many previous studies the order of measures [8, 66, 67], although one study which found a subjective-objective discrepancy reported that participants completed the self-report questionnaire before objective testing [11].

The domains of objective cognitive functioning in which participants performed least well were long- and short-term memory, although participants reported experiencing most difficulty in attention/concentration. This disparity could suggest that self-reporting ability in discrete domains of cognitive functioning, for example memory, is challenging as cognitive

domains overlap. This may have influenced similar studies which have assessed one domain of cognitive functioning. Results may be affected if participants identify cognitive difficulties in a different domain to that determined by objective tests. The use of a composite score comprised of various domains of cognitive functioning may have contributed to avoiding this potentially confounding factor, which may, therefore, have contributed to the finding of a subjective-objective correlation. Although objective and self-reported cognitive functioning were closely associated, the correlation was moderate in size (r=0.69) and, therefore, understanding why they may not be more closely associated remains important.

4.2. Psychological distress, attentional control and repetitive negative thinking

High levels of psychological distress were found to be associated with high levels of repetitive negative thinking and low levels of attentional control, in line with previous research [93]. The study found that in participants experiencing low or average levels of psychological distress, their self-reported and objective cognitive functioning scores were significantly related. However, for participants experiencing high levels of psychological distress their self-reported cognitive abilities were not significantly associated with the results of objective neuropsychological assessment. This supports previous research finding a close relationship between self-reported cognitive functioning and psychological distress [64]. However, the findings further this in specifying that the presence of high levels of psychological distress indicates that self-reported and objective results cease to be correlated. Psychological distress therefore may be a variable which, when experienced at high levels, influences how PWE perceive and report their cognitive abilities.

Attentional control, although closely associated with psychological distress, did not moderate the subjective-objective cognitive functioning relationship. A possible reason for

this may be that attentional control is a variable which might be reflected within the self-report measure (which asks about attention and concentration) as well as within the tests of objective cognitive functioning (which also assess aspects of attention).

Literature has shown heightened levels of repetitive negative thinking to be implicated in the development of psychological distress and to lead to an increase in self-judgemental thought content [28]. In exploring the role of repetitive negative thinking on the relationship between objective and self-report measures, a similar pattern to that of psychological distress was found. The results showed self-report and objective cognitive functioning were significantly associated for participants experiencing low or average levels of repetitive negative thinking. However, for participants experiencing high levels of repetitive negative thinking, there was no relationship between their self-report and objective scores. The presence of heightened levels of repetitive negative thinking, therefore, appears to be implicated in a lack of association between objective and self-report measures for PWE. This could lend support to previous theories that high levels of repetitive negative thinking lead to thought content which is increasingly self-judgmental [28]. For PWE who are at an increased likelihood of experiencing cognitive difficulties, this may include negative and judgemental thoughts regarding their cognitive abilities. This could warrant further investigation regarding the thought content of PWE experiencing discrepancies between their objective and self-reported cognitive abilities.

Attentional control was closely correlated to both psychological distress and repetitive negative thinking, but did not significantly moderate the objective-subjective relationship. Therefore, this queries whether shared attributes of repetitive negative thinking and psychological distress, not shared by attentional control, are key in influencing the subjective-

objective relationship. Further research would be necessary to separate out the variance on self-reported cognitive functioning attributed to these variables individually. In additional to the lack of moderation possibly being affected by attentional control being a similar concept to questions within the self-report measure, as attentional control was also measured through participants self-reporting, this may have meant the variables became too closely related. The moderation analysis was underpowered and it may be that a larger number of participants would be necessary to determine this relationship.

4.3. Strengths and limitations

Much previous research has solely considered the domain of memory [10, 65, 68]. As PWE can report difficulties within many domains of cognitive functioning, a strength of the current study is the use of a composite of domains of objective cognitive functioning as well as a measure of self-reported cognitive functioning which encompasses various aspects of cognitive functioning, including memory, attention, verbal fluency and executive functioning. Conversely a limitation of using a composite score was the loss of 38% of the variance in the objective cognitive functioning data. Additionally, using a composite meant that results for particular domains of cognition, such as memory, were not extracted and analysed separately. The analyses should also be interpreted cautiously due to the small sample size, which did not meet the required number and therefore did not achieve statistical power.

A limitation of the methodology of the study lies in measuring self-reported everyday cognitive functioning which, although it may have ecological validity, does not specifically allow for an estimation of the accuracy of PWE's perceptions of their performance on the objective cognitive functioning tests they have just completed. This would have required participants to estimate their performance on the tests using a similar scale as the tests

themselves. Results indicated 66% of the variance in subjective cognitive functioning was accounted for by psychological distress, objective scores and their interaction and 62% by repetitive negative thinking, objective cognitive functioning and their interaction. It is not known how much of this variance is the same for psychological distress and repetitive negative thinking, and what may explain the remaining variance. Potential factors may include the influence of social networks and the extent to which significant others inform the individual about their cognitive abilities. Additionally, a difficulty inherent in using neuropsychological tests stems from queries regarding their ecological validity. In using these assessments, it is important to retain awareness of the limitations they have, as well as their strengths [69]. A lack of ecological validity of objective tests may account for discrepancies with self-report measures and also some of the variance within self-reported cognitive functioning which is unaccounted for within the literature [70].

This study corroborates previous findings that PWE experience increased levels of anxiety and depression compared to the general population. However, this should be interpreted with caution as screening questionnaires were used to measure levels of anxiety and depression which, although well-validated [71], do not have full diagnostic utility. Additionally, as in previous studies, this study may have a population bias due to recruitment from epilepsy clinics and epilepsy support groups [72]. The participant sample was expected to be somewhat skewed to those with more intrusive epilepsy symptoms such as increased levels of uncontrolled seizures and more cognitive difficulties [73]. This is indicated by the quality of life measure which showed the participant sample had a lower level of wellbeing than the norm [59]. Additionally, around a third were using two or more AEDs. A limitation of the study is in understanding the type of epilepsy and frequency of seizures experienced by the participant group and the impact of this, due to this data not being collected. The

percentage of participants experiencing moderate or severe anxiety or depression was 42%, a higher proportion than that noted within the general population of people with epilepsy [14, 58].

4.4. Implications

Due to this study considering variables impacting upon cognitive ability which have not been previously examined, in addition to not achieving adequate power, there would be value in reiterating these findings in the future with a larger participant sample. Additionally, future research should attend to some of the methodological limitations of this study. For example, participants completing a task and subsequently rating their performance could address the variability which can occur due to different level of demands within participants' lives, and thus create a more standardised environment.

Within a clinical setting, this study highlights the importance of specialist assessment when PWE report cognitive decline, and a formulation which indicates the focus of an appropriate psychological intervention: whether it should target reducing a subjective-objective cognitive functioning discrepancy or, alternatively, cognitive decline. There are important ethical and clinical implications of the findings of this study. The findings indicate that individuals with low levels of psychological distress and/or repetitive negative thinking may report cognitive abilities closely associated with that found from neuropsychological testing. However, it is not implicated within this study that those with higher levels of anxiety, depression and/or repetitive negative thinking are always inaccurately perceiving their cognitive abilities and that these perceptions are necessarily detrimental. The study highlights the importance of a clinician developing an understanding of the complex interaction of subjective and objective cognitive abilities and psychological distress and repetitive negative

thinking. Particularly due to the limitations of objective measures, which may not reflect how an individual with epilepsy navigates cognitive demands in everyday life as well as self-report measures do. For example, an individual may be found to struggle with prospective memory, however does not rate this as a problem due to their partner's support in this area. Therefore, reducing an individual's objective-subjective cognitive abilities discrepancy may pose an ethical issue.

Interventions which target repetitive negative thinking and/ or psychological distress may help reduce the discrepancy between self-reported cognitive abilities and results of neuropsychological tests. Research into reducing repetitive negative thinking has indicated the value of cognitive-behavioural interventions and mindfulness-based strategies in helping change thinking styles [26]. Perceptions of cognitive deficit can substantially reduce quality of life in PWE [74] and findings from this study suggest that clinicians may, therefore, be able to increase quality of life in PWE who over-estimate cognitive deficit by targeting psychological distress and repetitive negative thinking. Previous research indicates that this could have positive repercussions for employment, education, relationships and confidence for PWE [75].

4.5. Conclusion

The findings of this study suggest that PWE experiencing low or average levels of repetitive negative thinking or psychological distress report their cognitive abilities as similar to results of objective assessments. However, when levels of psychological distress or repetitive negative thinking are high, a discrepancy between self-reported and objective cognitive functioning is apparent. Findings suggest that, for those under-estimating their cognitive abilities, interventions targeting repetitive negative thinking and psychological

distress may help address this. The findings support the necessity of an in-depth neuropsychological assessment for PWE reporting cognitive difficulties, considering psychological variables as well as psychometric assessment to tailor intervention to target psychological distress and/or cognitive difficulties.

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Appendices

Appendix A: Epilepsy and Behavior Author Guidelines

Article structure

Subdivision - numbered sections

Divide your article into clearly defined and numbered sections. Subsections should be numbered 1.1 (then 1.1.1, 1.1.2, ...), 1.2, etc. (the abstract is not included in section numbering). Use this numbering also for internal cross-referencing: do not just refer to 'the text'. Any subsection may be given a brief heading. Each heading should appear on its own separate line.

Introduction

State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Material and methods

Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described.

Results

Results should be clear and concise.

Discussion

The **Discussion** section should explore the significance of the results of the work, not repeat them. **Results** and **Discussion** should be separate and may be organized into subheadings. Avoid extensive citations and discussion of published literature.

Conclusions

The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.

Abstract

A concise and factual abstract is required. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this reason, References should be avoided, but if essential, then cite the author(s) and year(s). Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

Keywords

Immediately after the abstract, provide a maximum of 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.

Abbreviations

Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article. Such abbreviations that are unavoidable in the abstract must be defined at their first mention there, as well as in the footnote. Ensure consistency of abbreviations throughout the article.

Units

Follow internationally accepted rules and conventions: use the international system of units (SI). If other units are mentioned, please give their equivalent in SI.

Math formulae

Please submit math equations as editable text and not as images. Present simple formulae in line with normal text where possible and use the solidus (/) instead of a horizontal line for small fractional terms, e.g., X/Y. In principle, variables are to be presented in italics. Powers of e are often more conveniently denoted by exp. Number consecutively any equations that have to be displayed separately from the text (if referred to explicitly in the text).

Figure captions

Ensure that each illustration has a caption. Supply captions separately, not attached to the figure. A caption should comprise a brief title (**not** on the figure itself) and a description of the illustration. Keep text in the illustrations themselves to a minimum but explain all symbols and abbreviations used.

Tables

Please submit tables as editable text and not as images. Tables can be placed either next to the relevant text in the article, or on separate page(s) at the end. Number tables consecutively in accordance with their appearance in the text and place any table notes below the table body. Be sparing in the use of tables and ensure that the data presented in them do not duplicate results described elsewhere in the article. Please avoid using vertical rules and shading in table cells.

Reference style

Text: Indicate references by number(s) in square brackets in line with the text. The actual authors can be referred to, but the reference number(s) must always be given.

List: Number the references (numbers in square brackets) in the list in the order in which they appear in the text.

Examples:

Reference to a journal publication:

[1] Van der Geer J, Hanraads JAJ, Lupton RA. The art of writing a scientific article. J Sci Commun 2010;163:51–9.

Reference to a book:

[2] Strunk Jr W, White EB. The elements of style. 4th ed. New York: Longman; 2000.

Reference to a chapter in an edited book:

[3] Mettam GR, Adams LB. How to prepare an electronic version of your article. In: Jones BS, Smith RZ, editors. Introduction to the electronic age, New York: E-Publishing Inc; 2009, p. 281–304.

Reference to a website:

[4] Cancer Research UK. Cancer statistics reports for the UK, http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/; 2003 [accessed 13.03.03].

Reference to a dataset:

[dataset] [5] Oguro M, Imahiro S, Saito S, Nakashizuka T. Mortality data for Japanese oak wilt disease and surrounding forest compositions, Mendeley Data, v1; 2015. https://doi.org/10.17632/xwj98nb39r.1.

Note shortened form for last page number. e.g., 51–9, and that for more than 6 authors the first 6 should be listed followed by 'et al.' For further details you are referred to 'Uniform Requirements for Manuscripts submitted to Biomedical Journals' (J Am Med Assoc 1997;277:927–34) (see also Samples of Formatted References).

Appendix B: Criteria Checklist

	Not older adult (65+) or child	Diagnosis of Epilepsy and not post-surgery/ head injury/ other neurological condition	Peer reviewed, original study	Subjective cognitive functioning measure	Objective measure of attention/concentration and/or executive functioning (differentiated from overall cognitive functioning)	Relationship between self-reports and objective attention/executive functioning examined

Appendix C: Criteria from 16-item Quality Assessment Tool (QATSDD)

1. Explicit theoretical framework
2. Statement of aims/objectives in main body of report
3. Clear description of research setting
4. Evidence of sample size considered in terms of analysis
5. Representative sample of target group of a reasonable size
6. Description of procedure for data collection
7. Rationale for choice of data collection tool(s)
8. Detailed recruitment data
9. Statistical assessment of reliability and validity of measurement tools (Quantitative only)
10. Fit between stated research question and method of data collection (Quantitative only)
11. Fit between stated research question and format and content of data collection tool e.g. interview schedule (Qualitative only)
12. Fit between research question and method of analysis
13. Good justification for analytical method selected
14. Assessment of reliability of analytical process (Qualitative only)
15. Evidence of user involvement in design
16. Strengths and limitations critically discussed

Appendix D: Data extraction table

Study	Participants	Objective attention and executive functioning measure(s)	Self-reported cognitive functioning measure(s)	Relationship between objective and self-report measures	Psychological distress	Relationship between self-report and objective measures and psychological distress
Banos et al. (2004)	Participants who underwent evaluation for medically intractable seizures. 57 with LTLE, 36 with RTLE. LTLE mean age: 36.82 (10.14) RTLE mean age: 36.81 (10.59). Male: 38 Female: 55	Composite of Stroop Colour-Word Test and WAIS-R (Arithmetic and Digit Span)	Multiple Ability Self-Report Questionnaire (MASQ). Attention/Concentration subscale mean LTLE: 2.78 (0.52) Mean RTLE: 2.55 (0.665)	Hierarchal regression. 'No objective cognitive composite score significantly predicted MASQ in any domains'. No output provided.	WPSI and MMPI-II. LTLE group reported more problems with emotional adjustment (WPSI) and Depression and Schizophrenia Scales (MMPI-II).	Hierarchal regression. MMPI-II significantly predicted MASQ scores. Interpersonal Adjustment in WPSI significantly predicted verbal memory in MASQ, no other subtests of WPSI did.
Engelberts et al. (2002)	16 participants with well-controlled epilepsy, seizure free for two years, who had epilepsy for over 7 years but started after they finished high school. Mean age: 45.5. Males: 11 Female: 5 Type of epilepsy: 4 frontal lobe, 5 temporal	Stroop Colour-Word Test: Subtest I mean: 46.0 (8.6) Subtest II mean: 60.3 (10.6) Subtest III mean: 90.1 (15.6) Subtest IV mean: 29.0 (15.6) Categoric Word Fluency Task mean: 25.0 (5.8).	Cognitive Failure Questionnaire. Mean: 46.2 (13.7). Significantly lower scores in PWE than controls (p=.002, F=12.049)	Pearson's correlations. No statistically significant correlation between results of Stroop Test and Categoric Word Fluency Task and Cognitive Failure Questionnaire.	Profile of Mood States (Dutch Version)	Pearson's correlation. No correlation between Cognitive Failure Questionnaire and Profile of Mood States. Output not reported.

Study	Participants	Objective attention and executive functioning measure(s)	Self-reported cognitive functioning measure(s)	Relationship between objective and self-report measures	Psychological distress	Relationship between self-report and objective measures and psychological distress
	lobe, 6 frontotemporal, 1 occipital. Compared to healthy sample matched for education, gender and age. Mean age of controls: 45.5.	Compared to healthy matched controls no evidence of difficulty or impairments in PWE for Subtest III and IV (*F*=1.228; *F*=5.773). PWE statistically slower in Subtests I and II (*F*=7.686; *F*=11.59)		Output not reported.		
Fargo et al., 2003.	Patients from hospital for seizure monitoring and diagnosis. 45 participants with epilepsy, 37 participants with psychogenic nonepilepsy seizures (PNES). Mean age PWE: 34.66 (9.4). Male: 46.7% Female: 53.3%	Composite of: WAIS-III (Digit span and Arithmetic), WMS-III (Spatial Span) No significant differences between the two groups.	QOLIE-89 subscales of Memory, Language and Attention/ Concentration. Lower scores in each subscale for PNES group compared to PWE.	T-test: Significantly higher QOLIE-89 scores than objective composite (*t*[44]-5.71, *p*<.0001, *d*=1.11) in PWE. Stepwise multiple regression: Objective composite did not contribute to variance of	Composite of: Profile of Mood States and MMPI-II scales (Depression, Psychasthenia and Schizophrenia).	Pearson's correlation. Mood significantly correlated with QOLIE-89 subscale (attention/concentration) (*r*=-0.54). No correlations between objective composite and mood.

Study	Participants	Objective attention and executive functioning measure(s)	Self-reported cognitive functioning measure(s)	Relationship between objective and self-report measures	Psychological distress	Relationship between self-report and objective measures and psychological distress
				QOLIE-89 subscales		
Helmstaedter et al. (2010) '	Participants having AED change or with newly diagnosed epilepsy. 498 participants, 276 of these had already been taking an AED. Mean age: 46.2 (18.0) Male: 238 Female: 260	Epitrack No impairment: 46% Mild impairment: 16% Impairment: 38%	Self-rating health scale of 0-100 from best to worst imaginable health status. Three questions on cognitive capabilities, two on daily life activities' and two on AED tolerance. 62% were mildly to significantly impaired	Pearson's correlations. Significant correlation between EpiTrack and self-reports felt to be due to the large sample size (r=0.20, p<0.05))	WHO-5 questionnaire (depression).	Pearson's correlation. Correlation between self-reports and WHO-5 (r=0.57, p<0.001). No correlation between EpiTrack and WHO-5 (r=0.09, p>0.05)
Kampf et al., (2015)	40 participants. 15 symptomatic focal, 21 cryptogenic focal and 4 idiopathic generalised epilepsies. Mean age: 41.8 (16.1) Male: 16 Female: 24	EpiTrack mean: 29.5 (5.7). 'Pathological' result: 23.1% (n=9).	c.I.-Skala Mean score: 13.5 (9.3). 'Pathological': 28.2% (n=11).	Significant relationship between EpiTrack and c.I. –Skala (r=-0.33, p<0.04)	Self-Rating Depression Scale. State Trait Anxiety Inventory	c.I.-Skala and depression significantly correlated (r= 0.65, p< 0.000005), c.I.-Skala and anxiety significantly correlated (r=0.56, p<0.0007; r=0.56, p<0.0002).

Study	Participants	Objective attention and executive functioning measure(s)	Self-reported cognitive functioning measure(s)	Relationship between objective and self-report measures	Psychological distress	Relationship between self-report and objective measures and psychological distress
						EpiTrack not significantly correlated to depression or anxiety.
Karkoska et al., (2015)	34 participants. Epilepsy type: 2 simple partial, 20 complex partial, 7 simple and complex partial seizures, 5 generalised epilepsies. Mean age: 41.2 (13.3) Male: 20.6% Female: 79.4%	EpiTrack mean: 25.76 (7.05) Stroop Test Subtest I mean: 38.09 (11.07) Stroop Test Subtest II mean: 55.82 (15.79) Stroop Test Subtest III mean: 101.91 (42.88)	Fragebogen zur geistigen Leistungsfahigkeit (FLei) Mean: 41.14 (23.89)	Pearson's correlation. Significant correlation between EpiTrack and FLei.	Hospital Anxiety and Depression Scale (HADS)	Multiple regression: 42% (p<0.05) of variance of FLei explained by HADS.
Liik et al., (2009) '	62 participants Male: 25 Female: 37 Mean age: 34.6 (11). Epilepsy type: 2 simple partial and complex partial, 5 complex partial, 28 complex partial and secondarily generalised seizures, 9 generalised seizures, 18 generalised tonic clonic	Symbol Digit Modalities Test and Trail Making 1 and 2. Descriptive statistics not reported.	A subjective complaints questionnaire (Toomela et al, 2004) with added epilepsy specific items	Pearson's correlation: No significant correlation between self-reported and objective measures.	Beck Depression Inventory (BDI)	Linear regression: Self-reports significantly correlated with BDI (r^2=0.362, p<0.05). 36% of self-report measure can be explained by BDI.

Study	Participants	Objective attention and executive functioning measure(s)	Self-reported cognitive functioning measure(s)	Relationship between objective and self-report measures	Psychological distress	Relationship between self-report and objective measures and psychological distress
	seizures. 35 partial epilepsy, 10 TLE, 27 idiopathic generalised epilepsy					
Marino et al., (2009)	192 PWE using either lamotrigine or topiramate Male: 116 Female: 76 Mean age: 40 (13).	Stroop Colour-Word Interference mean: 82.3 (25.2) for participants using lamotrigine and 81.9 (27.1) for participants using topiramate. Digit Cancellation mean: 347.0 (119) for participants using lamotrigine and 377.5 (110) for participants using topiramate.	QOLIE-89 measures of attention, language and memory	No correlations between objective and self-report measures	Center for Epidemiological Studies Depression Scale (CES-D) Profile of Mood States (POMS)	Bivariate correlations. Significant correlations for PWE taking lamotrigine between QOLIE-89 subscales and CES-D and POMS (p<0.01, r values ranging from -0.316 to 0.626) For PWE taking topiramate five of eight measures of CES-D and POMS correlate with QOLIE-89 subscales. For PWE taking lamotrigine: no correlation with POMS and objective measures. For PWE taking topiramate: Objective measures correlated with POMS-Depression (r=0.349, p< 0.005)

Study	Participants	Objective attention and executive functioning measure(s)	Self-reported cognitive functioning measure(s)	Relationship between objective and self-report measures	Psychological distress	Relationship between self-report and objective measures and psychological distress
Meneses et al. (2009)	71 participants. Epilepsy types: 47 temporal, 13 frontal, 9 frontotemporal, 2 frontoparietal. Male: 31 Female: 40 Mean age 37.48 (11.79)	Attentive Matrices mean: 49.17 (9.24)	ESI-55 subscale: Cognitive Functioning. Mean: 60.31 (23.76)	Pearson's correlation. No significant correlation between ESI-55 and Attentive Matrices	Portugese version of SF-36v1.0: Mental Health Component	Attentive Matrices significantly correlated with Mental Health Component. No output provided.
Samaraseker a et al. (2015)	82 participants with epilepsy. Each participant also had a caregiver. Mean age: 40 Male: 38 Female: 44 Epilepsy type: 63 structural/ metabolic, 15 genetic generalised, 4 unspecified	Epitrack. Significant cognitive impairment: 34% on monotherapy 64% on two AED 71% on three or more AEDs.	A-B Neuropsychological Assessment Schedule (ABNAS): 81.7% of patients scored themselves as 'high' cognitive dysfunction. Significantly more participants using two or more AEDs scored themselves as 'high' cognitive dysfunction.	Stepwise linear regression. Participants with 'impaired' objective scores: concordance of EpiTrack with ABNAS: 84.7%. Participants with 'unimpaired' objective scores: concordance with ABNAS: 30.4%.	HADS	EpiTrack and ABNAS both significantly correlated with HADS. Greater correlation between HADS and ABNAS than with EpiTrack. Output not provided.

Study	Participants	Objective attention and executive functioning measure(s)	Self-reported cognitive functioning measure(s)	Relationship between objective and self-report measures	Psychological distress	Relationship between self-report and objective measures and psychological distress
Witt et al. (2012)	Data extracted from pharmacological non-interventional study. 247 participants Male: 135 Female: 112 Mean age: 47 (18.8). Epilepsy type: 119 symptomatic epilepsy, 27 cryptogenic epilepsy, 61 idiopathic epilepsy.	EpiTrack mean: 27.6 (6.2) 'Mild impairment': 19% 'Marked impairment': 30.4%.	2 questions on self-perceived deficits in concentration and memory in last two weeks on Likert scale. 24.7% reported mild deficits, 4% marked deficits in attention.	Concordance between self-reports and EpiTrack seen in 49.4%.	Question on 'psychic well-being'	'Psychic wellbeing' did not correlate with EpiTrack (r=-0.03, p>0.05)

Abbreviations: Multiple Abilities Self-Report Questionnaire (MASQ), left temporal lobe epilepsy (LTLE), right temporal lobe epilepsy (RTLE), Washington Psychosocial Seizure Inventory (WPSI), Minnesota-Multiphasic Personality Inventory (MMPI-II), psychogenic nonepilepsy seizures (PNES), Wechsler Adult Intelligence Scale- Third Edition (WAIS-III), Wechsler Memory Scale- Third Edition (WMS-III), Quality of Life in Epilepsy Inventory (QOLIE-89), anti-epilepsy medication (AED), Hospital Anxiety and Depression Scale (HADS), Beck Depression Inventory (BDI) Center for Epidemiological Studies Depression Scale (CES-D), Profile of Mood States (POMS), A-B Neuropsychological Assessment Schedule (ABNAS)

Appendix E: Quality assessment table

	Banos 2004	Engelberts 2002	Fargo 2004	Helmstaedter 2010	Kampf 2016	Karkoska 2015	Liik 2009	Marino 2009	Meneses 2009	Samarasekera 2015	Witt 2012
Explicit theoretical framework	1	1	1	1	1	1	2	2	3	1	1
Statement of aims/objectives in main body of report	1	2	2	3	2	3	3	2	2	3	2
Clear description of research setting	1	3	3	1	1	3	3	0	2	3	2
Evidence of sample size considered in terms of analysis	0	0	0	0	0	0	0	0	2	2	0
Representative sample of target group of a reasonable size	2	1	2	2	1	2	3	2	3	3	3
Description of procedure for data collection	2	2	3	2	1	2	1	1	2	2	1
Rationale for choice of data collection tool(s)	2	1	1	2	2	2	1	1	3	2	2
Detailed recruitment data	2	2	3	3	1	2	2	1	2	2	2

	Banos 2004	Engelberts 2002	Fargo 2004	Helmstaedter 2010	Kampf 2016	Karkoska 2015	Liik 2009	Marino 2009	Meneses 2009	Samarasekera 2015	Witt 2012
Statistical assessment of reliability and validity of measurement tools (Quantitative)	2	1	0	0	0	0	0	0	1	2	1
Fit between stated research question and method of data collection (Quantitative)	3	3	3	2	2	3	3	3	3	3	3
Fit between research question and method of analysis	2	3	3	3	3	3	3	2	3	3	3
Good justification for analytical method selected	1	3	3	1	2	1	2	2	3	2	2
Evidence of user involvement in design	0	0	0	0	0	0	0	0	0	0	0
Strengths and limitations critically discussed	2	1	2	2	2	1	2	2	2	2	1
Overall score (percentage of total possible score)	21 (50%)	23 (55%)	26 (62%)	22 (52%)	18 (43%)	23 (55%)	25 (60%)	18 (43%)	31 (74%)	30 (71%)	23 (55%)

Appendix F: Notice of ethical approval

NHS
Health Research Authority
National Research Ethics Service

North West - Lancaster Research Ethics Committee
Barlow House
3rd Floor
4 Minshull Street
Manchester
M1 3DZ

Telephone: 020 71048008

05 January 2016

Dr Pierce O'Carroll
Whelan Building
Brownlow Hill
University of Liverpool
L69 3GB

Dear Dr O'Carroll

Study title:	**The relationship between objective cognitive ability and subjective cognitive ability and the moderating role of attentional control and perseverative thinking in people with epilepsy.**
REC reference:	**15/NW/0958**
Protocol number:	**UoL001181**
IRAS project ID:	**189754**

Thank you for responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

We plan to publish your research summary wording for the above study on the HRA website, together with your contact details. Publication will be no earlier than three months from the date of this opinion letter. Should you wish to provide a substitute contact point, require further information, or wish to make a request to postpone publication, please contact the REC Manager, Mrs Carol Ebenezer, nrescommittee.northwest-lancaster@nhs.net.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Conditions of the favourable opinion

The REC favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements. Each NHS organisation must confirm through the signing of agreements and/or other documents that it has given permission for the research to proceed (except where explicitly specified otherwise).

Guidance on applying for NHS permission for research is available in the Integrated Research Application System, www.hra.nhs.uk or at http://www.rdforum.nhs.uk.

Where a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of management permissions from host organisations

Registration of Clinical Trials

All clinical trials (defined as the first four categories on the IRAS filter page) must be registered on a publically accessible database within 6 weeks of recruitment of the first participant (for medical device studies, within the timeline determined by the current registration and publication trees).

There is no requirement to separately notify the REC but you should do so at the earliest opportunity e.g. when submitting an amendment. We will audit the registration details as part of the annual progress reporting process.

To ensure transparency in research, we strongly recommend that all research is registered but for non-clinical trials this is not currently mandatory.

If a sponsor wishes to contest the need for registration they should contact Catherine Blewett (catherineblewett@nhs.net), the HRA does not, however, expect exceptions to be made. Guidance on where to register is provided within IRAS.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Ethical review of research sites

NHS sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Evidence of Sponsor insurance or indemnity (non NHS Sponsors only) [University of Liverpool, Marsh]		05 August 2015
Letter from sponsor [Sponsorship Approval]	1	21 October 2015
Other [Research Review Committee Letter]		10 September 2015
Other [Clarification re Perry Moore]		27 November 2015
Participant consent form	4	30 December 2015
Participant information sheet (PIS)	4	30 December 2015
REC Application Form [REC_Form_27112015]	5.1.0	27 November 2015
Research protocol or project proposal [Research Proposal]	2	15 July 2015
Summary CV for Chief Investigator (CI) [Pierce O'Carroll CV]		12 December 2014
Summary CV for student [Layla Mottahedin-Fardo]		18 October 2015
Summary CV for supervisor (student research) [Perry Moore Supervisor]		18 November 2015
Validated questionnaire [PHQ-9]		
Validated questionnaire [GAD-7]		
Validated questionnaire [Perceived Deficits Questionnaire]		
Validated questionnaire [Perseverative Thinking Questionnaire]		
Validated questionnaire [Attentional Control Scale]		
Validated questionnaire [QOLIE-31]		
Validated questionnaire [DKEFS Page 1]		
Validated questionnaire [DKEFS Page 2]		
Validated questionnaire [WMS-IV]		
Validated questionnaire [WAIS-IV]		

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Reporting requirements

The attached document *"After ethical review – guidance for researchers"* gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports

- Notifying the end of the study

The HRA website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

User Feedback

The Health Research Authority is continually striving to provide a high quality service to all applicants and sponsors. You are invited to give your view of the service you have received and the application procedure. If you wish to make your views known please use the feedback form available on the HRA website: http://www.hra.nhs.uk/about-the-hra/governance/quality-assurance/

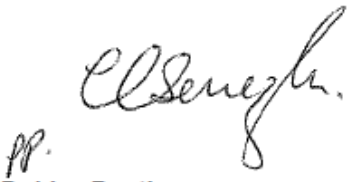
HRA Training

We are pleased to welcome researchers and R&D staff at our training days – see details at http://www.hra.nhs.uk/hra-training/

15/NW/0958	**Please quote this number on all correspondence**

With the Committee's best wishes for the success of this project.

Yours sincerely



Dr Lisa Booth
Chair

Email:nrescommittee.northwest-lancaster@nhs.net

Enclosures: "After ethical review – guidance for researchers"

Copy to: *Mr Alex Astor*
Mr Dave Watling, The Walton Centre

Appendix G: Participant information sheet

PARTICIPANT INFORMATION SHEET

The relationship between objective cognitive ability and subjective cognitive ability and the moderating role of attentional control and perseverative thinking in people with epilepsy

Thank you for considering being part of this research project. Before you decide whether or not you would like to take part please read the following information carefully.

This information sheet gives more details about the study but if anything is not clear or if you would like more information before you make a decision, please ask the researcher.

What is the purpose of the study?
People with epilepsy can sometimes experience changes to their cognitive abilities, for example changes to memory or concentration. You may or may not have noticed this yourself. This study looks at whether different thinking styles affect what your perceptions of your memory, concentration and other cognitive abilities are. By knowing more about this we can develop ways of helping, for example by reducing anxiety and worry.

Why have I been asked to take part?
You have been asked to take part as you are an adult with epilepsy.

Do I have to take part?
No. You do not have to take part, it is entirely up to you. You can stop taking part at any point without giving a reason and ask for the results to be destroyed. Whether you decide to take part or not will not affect the service you are receiving from the Walton Centre.

What would it involve?
You will be asked to complete some cognitive assessments and questionnaires. The questionnaires will look at:

- Quality of life
- Perceptions of cognitive abilities
- Perseverative thinking
- Attentional control
- A brief measure of depression
- A brief measure of anxiety

The cognitive assessments will assess:

- Memory
- Attention and processing speed
- Planning and organising

It will take around 45minutes-1hour to complete. The researcher will not be able to tell you your results.

If you decide to take part you can complete the measures and questionnaires at the Walton Centre or make an appointment for a researcher to meet you at your home. Travel expenses will be reimbursed if you prefer to return to the Walton Centre on a different day to take part.

Will my taking part in the study be kept confidential?
Yes. All information you provide will be kept completely confidential. All personal information (e.g. your name) or anything else which might identify you will be removed so that no-one will know who you are. The information that you provide will **not** be shared with anyone in the Walton Centre who is not part of the research team.

Some data may be used from your medical records so that we do not ask you questions we already have information on. This data will only be accessed by members of your clinical care team and will remain confidential.

The only exception to confidentiality is if the information that you provide suggests that you or someone else may be at risk of harm. In the rare circumstances when this does happen the researcher will make every effort to discuss this with you first. Information will be stored securely within the Walton Centre and the University of Liverpool in accordance with the Data Protection Act 1998.

What are the possible benefits of taking part?
The information that you give us can increase our understanding and help us to improve services and support given to people with epilepsy in the future. You can also take part in a prizedraw with a chance to win one of three £50 shopping vouchers.

Are there any risks/disadvantages to helping with this research?
It is not expected to be any risks in taking part in the research, the only disadvantage could be the time the research is expected to take, which may be up to an hour. However if any part of the research distresses you please tell the researcher.

Who has reviewed the study?
All research in the NHS is looked at by an independent group, called a Research Ethics Committee, to protect your interests. This study has been reviewed and given ethical approval.

Who has funded this study?
This study has been funded by the Northwest Strategic Health Authority via the Doctorate of Clinical Psychology Programme, Division of Clinical Psychology, University of Liverpool.

What will happen to the results of the study?
The results of this study will be written up as a thesis in partial fulfilment of the lead researcher's qualification of Doctorate in Clinical Psychology.

It is expected that the results of the study will be written up in a scientific journal and will help to develop services for people with epilepsy. You will not be identifiable in any publication.

What if I am unhappy or if there is a problem?
If you are unhappy or have a problem during the research you can contact Layla Mottahedin-Fardo, email: laylam@liverpool.ac.uk or phone 0151 794 5102. If you remain unhappy you can contact Dr Adam Noble (Primary Research Supervisor), phone: 0151 794 5993. If you

remain unhappy and wish to complain formally, you can do this through the NHS Complaints Procedure using the Patient Advisory Liaison Service (PALS), phone: 0151 556 3090.

Who can I contact if I have further questions?
Please contact Layla Mottahedin-Fardo via email: laylam@liverpool.ac.uk if you have any further questions or phone 0151 794 5102.

Participant Consent Form

Title: The relationship between objective cognitive ability and subjective cognitive ability and the moderating role of attentional control and perseverative thinking in people with epilepsy

Researchers: Layla Mottahedin-Fardo, Dr Perry Moore, Dr Adam Noble, Professor Tony Marson

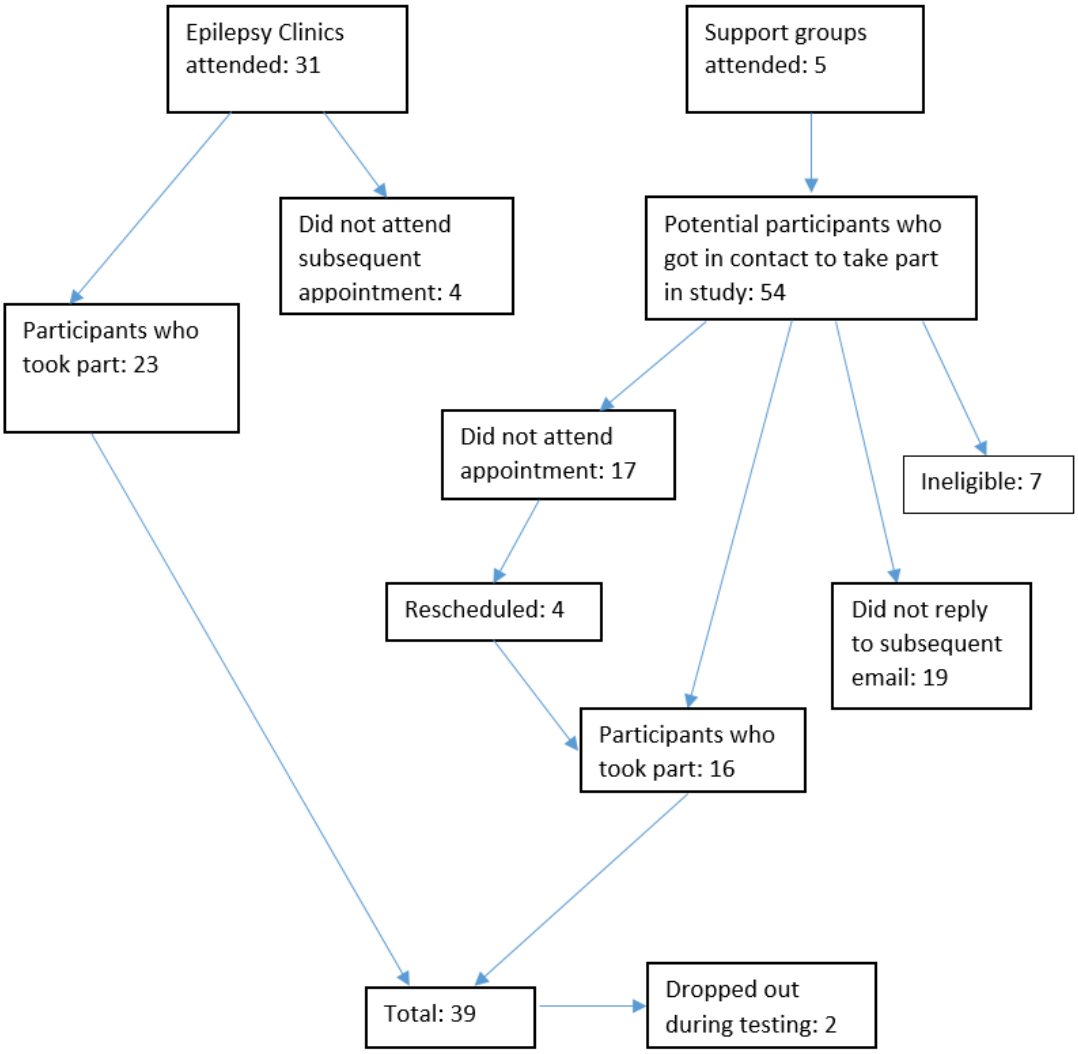
	Please initial box
1. I confirm that I have read and have understood the information sheet dated 11/07/2016 (Version 6) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my medical care or legal rights being affected.	☐
3. I understand that data from the questionnaires I complete will be part of this study without giving my name or disclosing my identity.	☐
4. I understand that no information from my completed questionnaires will be shared with any other participant in the study.	☐
5. I agree that anonymised data from the study may be used in future studies which have been given ethical approval.	☐
6. I understand that data from the study may be looked at by regulatory authorities and by persons from the Trust where it is relevant to my taking part in this research. I give permission for these individuals to have access to this data	☐

Name of participant	Date	Signature
Name of researcher	Date	Signature

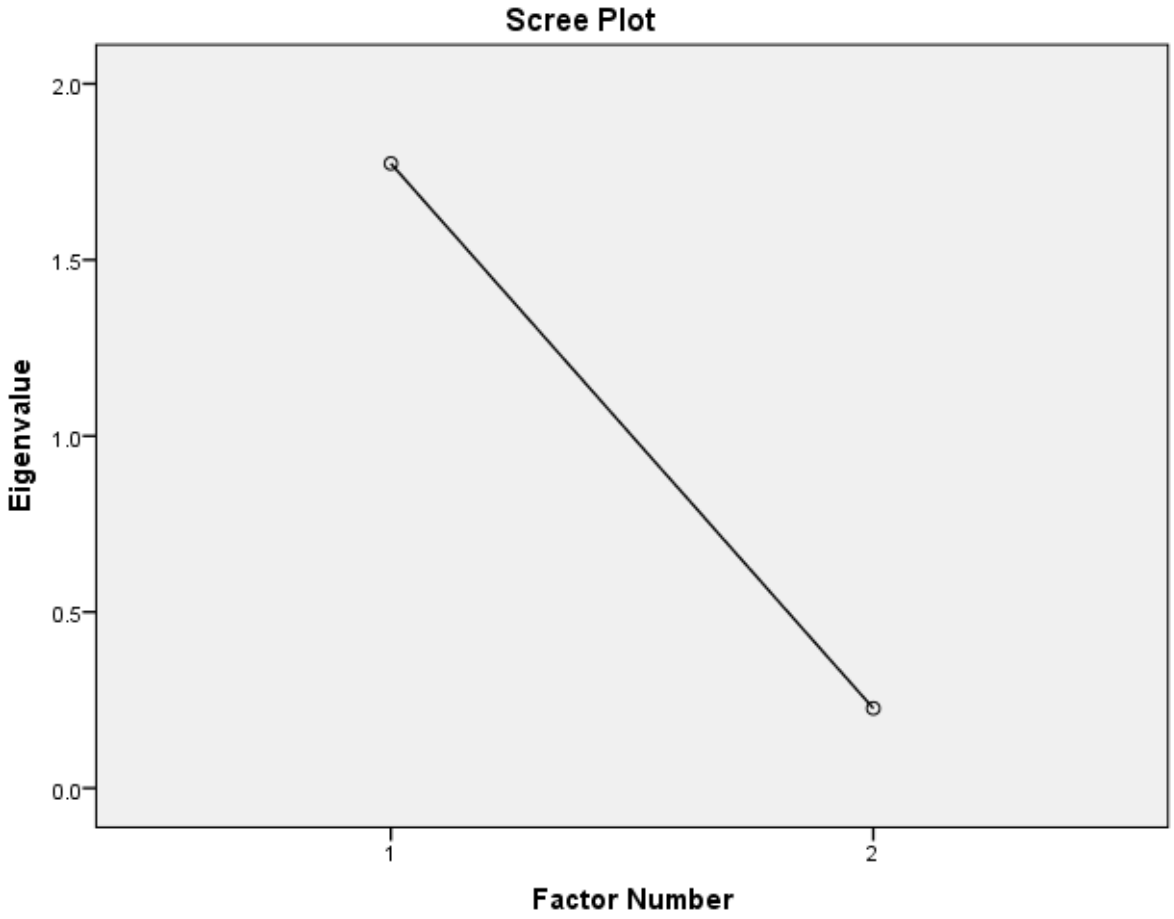
If you have any queries the contact details of the Lead Researcher are:
Layla Mottahedin-Fardo, University of Liverpool laylam@liverpool.ac.uk

Thank you for taking time to participate in this research

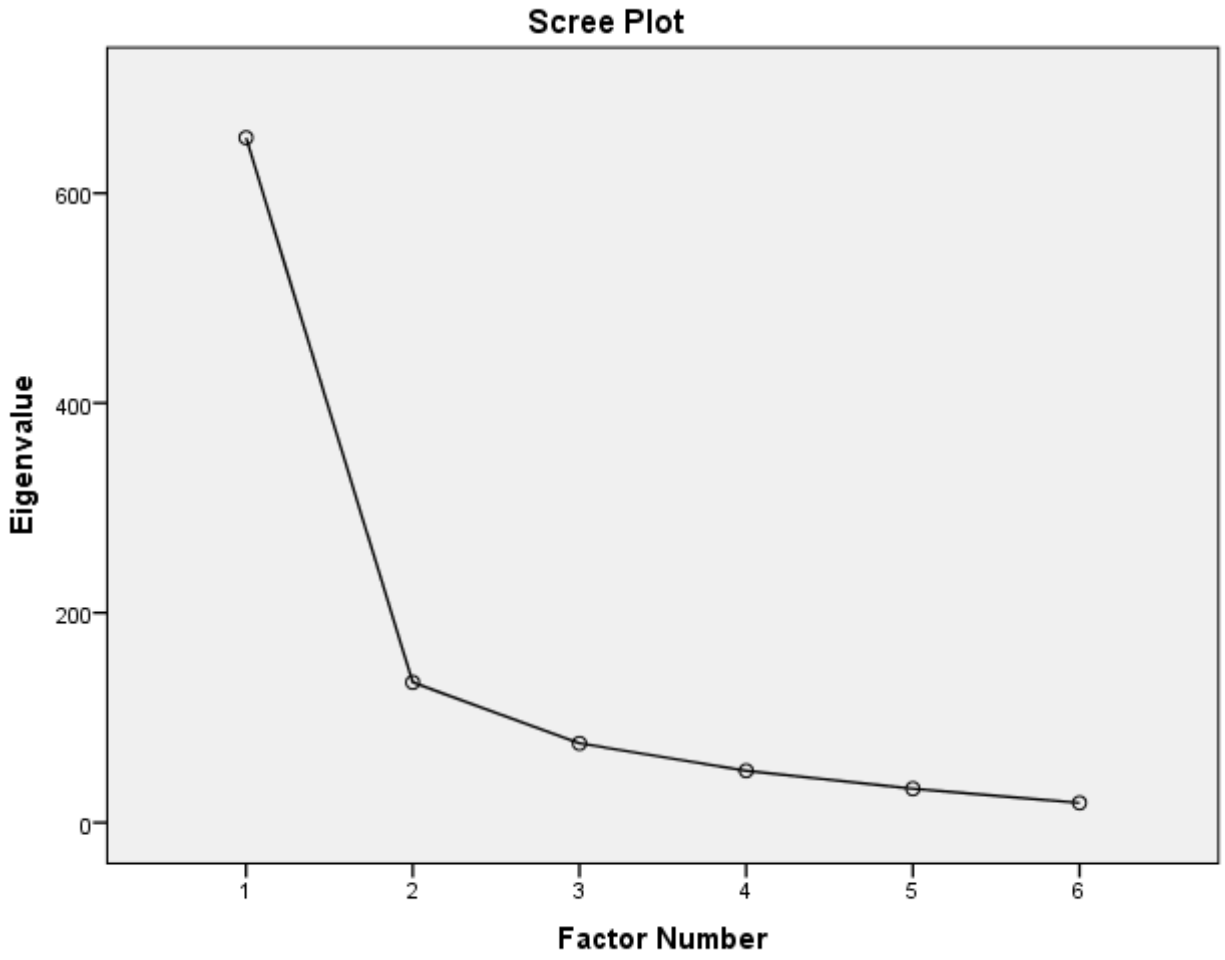
Appendix J: Recruitment data



Appendix K: Scree plot showing factor loadings for Psychological Distress



Appendix L: Scree plot showing factor loadings for Objective Cognitive Functioning

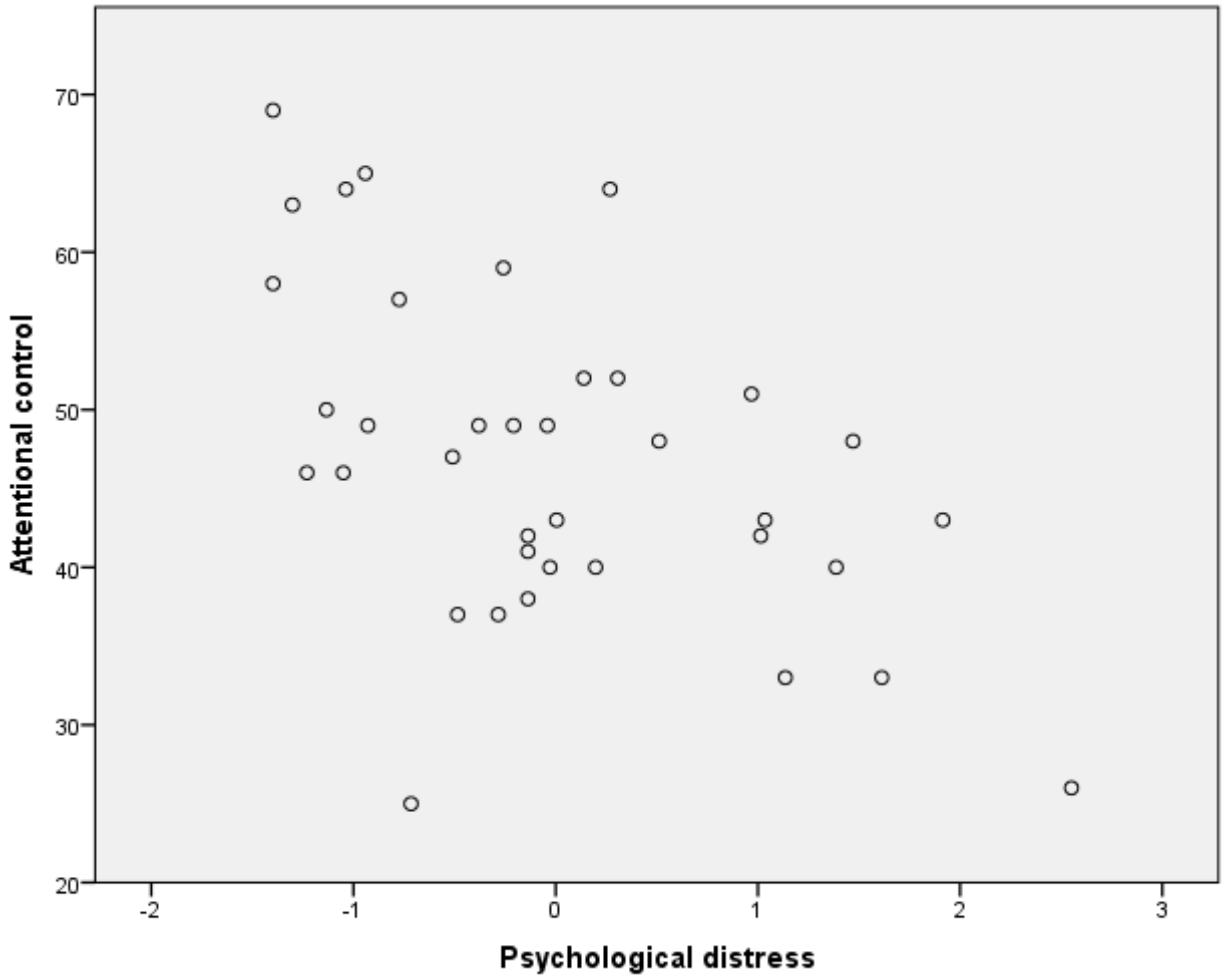


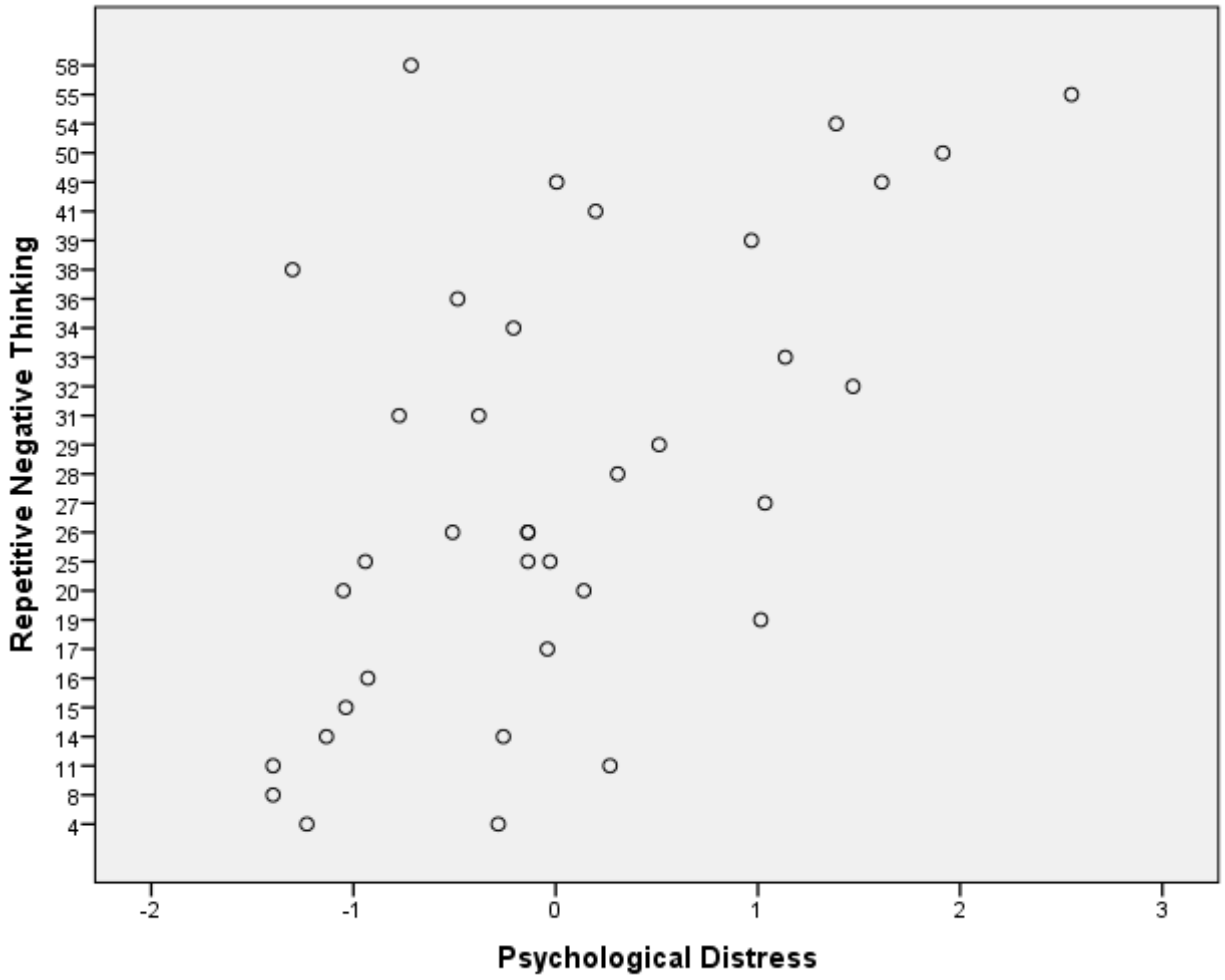
Appendix M: Correlation matrix for Psychological Distress, Attentional Control and Repetitive Negative Thinking

		Attentional control	Repetitive negative thinking	Psychological distress
Attentional control	Pearson Correlation	1	-.544**	-.522**
	Sig. (2-tailed)		.000	.001
	N	37	37	37
Repetitive negative thinking	Pearson Correlation	-.544**	1	.567**
	Sig. (2-tailed)	.000		.000
	N	37	37	37
Psychological distress	Pearson Correlation	-.522**	.567**	1
	Sig. (2-tailed)	.001	.000	
	N	37	37	37

** Correlation is significant at the 0.01 level (2-tailed)

Appendix N: Scatterplots showing the relationship between Psychological Distress and Attentional Control; Psychological Distress and Repetitive Negative Thinking; Repetitive Negative Thinking and Attentional Control.




Repetitive Negative Thinking
58
55
54
50
49
41
39
38
36
34
33
32
31
29
28
27
26
25
20
19
17
16
15
14
11
8
4
-2
-1
0
1
2
3
Psychological Distress

Appendix O: Output of self-reported and objective cognitive functioning correlational analysis

		Objective cognitive functioning	Self-reported cognitive functioning
Objective cognitive functioning	Pearson Correlation	1	-.693**
	Sig. (2-tailed)		.000
	N	37	37
Self-reported cognitive functioning	Pearson Correlation	-.693**	1
	Sig. (2-tailed)	.000	
	N	37	37

** Correlation is significant at the 0.01 level (2-tailed).

Appendix P: SPSS output of moderation analysis of the effect of Self-Reported Cognitive Functioning on Objective Cognitive Functioning using Psychological Distress as a potential moderator.

```
Run MATRIX procedure:

************* PROCESS Procedure for SPSS Release 2.16.1 ******************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 1
    Y = SCF
    X = OCF
    M = anxdep

Sample size
         37

**************************************************************************
Outcome: SCF

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .8154      .6648    77.2570    18.4355     3.0000    33.0000      .0000

Model
              coeff         se          t          p       LLCI       ULCI
constant    43.2874     1.5315    28.2649      .0000    40.1715    46.4033
anxdep       6.2651     1.7958     3.4888      .0014     2.6116     9.9187
OCF          -.6574      .1246    -5.2742      .0000     -.9110     -.4038
int_1         .3539      .1403     2.5234      .0166      .0686      .6393

Product terms key:

 int_1    OCF         X     anxdep

R-square increase due to interaction(s):
         R2-chng          F        df1        df2          p
int_1      .0660     6.3676     1.0000    33.0000      .0166

**************************************************************************

Conditional effect of X on Y at values of the moderator(s):
     anxdep     Effect         se          t          p       LLCI       ULCI
    -1.0000    -1.0113      .2135    -4.7358      .0000    -1.4458     -.5768
      .0000     -.6574      .1246    -5.2742      .0000     -.9110     -.4038
     1.0000     -.3034      .1575    -1.9263      .0627     -.6239      .0170

Values for quantitative moderators are the mean and plus/minus one SD from mean.
Values for dichotomous moderators are the two values of the moderator.

********************** JOHNSON-NEYMAN TECHNIQUE ***************************

Moderator value(s) defining Johnson-Neyman significance region(s)
      Value    % below    % above
      .9683    78.3784    21.6216

Conditional effect of X on Y at values of the moderator (M)
```

anxdep	Effect	se	t	p	LLCI	ULCI
-1.3977	-1.1521	.2617	-4.4020	.0001	-1.6846	-.6196
-1.2003	-1.0822	.2374	-4.5588	.0001	-1.5652	-.5992
-1.0029	-1.0123	.2139	-4.7331	.0000	-1.4475	-.5772
-.8054	-.9425	.1915	-4.9216	.0000	-1.3321	-.5528
-.6080	-.8726	.1707	-5.1127	.0000	-1.2198	-.5253
-.4106	-.8027	.1521	-5.2792	.0000	-1.1121	-.4933
-.2132	-.7328	.1365	-5.3669	.0000	-1.0106	-.4550
-.0157	-.6629	.1253	-5.2903	.0000	-.9179	-.4080
.1817	-.5931	.1196	-4.9602	.0000	-.8363	-.3498
.3791	-.5232	.1201	-4.3566	.0001	-.7675	-.2789
.5766	-.4533	.1268	-3.5746	.0011	-.7113	-.1953
.7740	-.3834	.1388	-2.7618	.0093	-.6659	-.1010
.9683	-.3146	.1547	-2.0346	.0500	-.6293	.0000
.9714	-.3136	.1549	-2.0239	.0511	-.6288	.0016
1.1688	-.2437	.1740	-1.4008	.1706	-.5976	.1102
1.3663	-.1738	.1951	-.8909	.3794	-.5707	.2231
1.5637	-.1039	.2177	-.4774	.6362	-.5468	.3390
1.7611	-.0341	.2413	-.1411	.8886	-.5251	.4570
1.9586	.0358	.2658	.1348	.8936	-.5049	.5766
2.1560	.1057	.2908	.3635	.7186	-.4860	.6974
2.3534	.1756	.3163	.5551	.5825	-.4679	.8191
2.5508	.2455	.3421	.7175	.4781	-.4506	.9415

```
**************************************************************************

Data for visualizing conditional effect of X on Y
Paste text below into a SPSS syntax window and execute to produce plot.

DATA LIST FREE/OCF anxdep SCF.
BEGIN DATA.

   -12.5172    -1.0000    49.6811
     .0000    -1.0000    37.0222
   12.5172    -1.0000    24.3634
   -12.5172      .0000    51.5159
     .0000      .0000    43.2874
   12.5172      .0000    35.0588
   -12.5172     1.0000    53.3508
     .0000     1.0000    49.5525
   12.5172     1.0000    45.7543

END DATA.
GRAPH/SCATTERPLOT=OCF WITH SCF BY anxdep.

******************** ANALYSIS NOTES AND WARNINGS ************************

Level of confidence for all confidence intervals in output:
    95.00

NOTE: The following variables were mean centered prior to analysis:
 OCF      anxdep

NOTE: All standard errors for continuous outcome models are based on the HC3 estimator

------ END MATRIX -----
```

Appendix Q: SPSS output of moderation analysis of the effect of Self-Reported Cognitive Functioning on Objective Cognitive Functioning using Attentional Control as a potential moderator.

```
Run MATRIX procedure:

************* PROCESS Procedure for SPSS Release 2.16.1 ******************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 1
    Y = SCF
    X = OCF
    M = ACS

Sample size
         37

**************************************************************************
Outcome: SCF

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .7929      .6287    85.5801    20.1401     3.0000    33.0000      .0000

Model
              coeff         se          t          p       LLCI       ULCI
constant    42.1432     2.0055    21.0135     .0000    38.0628    46.2235
ACS          -.5800      .2498    -2.3213     .0266    -1.0883     -.0716
OCF          -.5855      .1334    -4.3901     .0001     -.8568     -.3142
int_1        -.0050      .0223     -.2233     .8247     -.0504      .0404

Product terms key:

 int_1    OCF         X     ACS

R-square increase due to interaction(s):
         R2-chng          F        df1        df2          p
int_1      .0012      .0499     1.0000    33.0000      .8247

**************************************************************************

Conditional effect of X on Y at values of the moderator(s):
        ACS     Effect         se          t          p       LLCI       ULCI
   -10.5158     -.5331      .2727    -1.9552     .0591    -1.0879     .0216
     .0000     -.5855      .1334    -4.3901     .0001     -.8568     -.3142
    10.5158     -.6379      .2669    -2.3898     .0227    -1.1809     -.0948

Values for quantitative moderators are the mean and plus/minus one SD from mean.
Values for dichotomous moderators are the two values of the moderator.

********************* JOHNSON-NEYMAN TECHNIQUE ***************************

Moderator value(s) defining Johnson-Neyman significance region(s)
      Value    % below    % above
    13.1955    86.4865    13.5135
   -10.0280    10.8108    89.1892
```

```
Conditional effect of X on Y at values of the moderator (M)
        ACS     Effect         se          t          p       LLCI       ULCI
   -21.9730     -.4761      .5111     -.9315      .3584    -1.5159      .5637
   -19.7730     -.4870      .4639    -1.0499      .3014    -1.4308      .4568
   -17.5730     -.4980      .4171    -1.1938      .2411    -1.3467      .3507
   -15.3730     -.5089      .3710    -1.3719      .1793    -1.2637      .2458
   -13.1730     -.5199      .3257    -1.5965      .1199    -1.1825      .1427
   -10.9730     -.5309      .2816    -1.8851      .0682    -1.1038      .0421
   -10.0280     -.5356      .2632    -2.0346      .0500    -1.0711      .0000
    -8.7730     -.5418      .2395    -2.2621      .0304    -1.0291     -.0545
    -6.5730     -.5528      .2006    -2.7553      .0095     -.9609     -.1446
    -4.3730     -.5637      .1672    -3.3722      .0019     -.9038     -.2236
    -2.1730     -.5747      .1430    -4.0180      .0003     -.8657     -.2837
      .0270     -.5856      .1334    -4.3916      .0001     -.8570     -.3143
     2.2270     -.5966      .1412    -4.2265      .0002     -.8838     -.3094
     4.4270     -.6076      .1640    -3.7055      .0008     -.9411     -.2740
     6.6270     -.6185      .1966    -3.1459      .0035    -1.0185     -.2185
     8.8270     -.6295      .2350    -2.6782      .0114    -1.1077     -.1513
    11.0270     -.6404      .2768    -2.3133      .0271    -1.2037     -.0772
    13.1955     -.6512      .3201    -2.0346      .0500    -1.3024      .0000
    13.2270     -.6514      .3207    -2.0310      .0504    -1.3039      .0011
    15.4270     -.6623      .3659    -1.8101      .0794    -1.4068      .0821
    17.6270     -.6733      .4120    -1.6342      .1117    -1.5115      .1649
    19.8270     -.6842      .4587    -1.4917      .1453    -1.6175      .2490
    22.0270     -.6952      .5058    -1.3743      .1786    -1.7244      .3340

************************************************************************

Data for visualizing conditional effect of X on Y
Paste text below into a SPSS syntax window and execute to produce plot.

DATA LIST FREE/OCF ACS SCF.
BEGIN DATA.

   -12.5172   -10.5158    54.9152
      .0000   -10.5158    48.2419
    12.5172   -10.5158    41.5686
   -12.5172       .0000    49.4720
      .0000       .0000    42.1432
    12.5172       .0000    34.8143
   -12.5172    10.5158    44.0289
      .0000    10.5158    36.0445
    12.5172    10.5158    28.0601

END DATA.
GRAPH/SCATTERPLOT=OCF WITH SCF BY ACS.

****************** ANALYSIS NOTES AND WARNINGS *************************

Level of confidence for all confidence intervals in output:
    95.00

NOTE: The following variables were mean centered prior to analysis:
 OCF      ACS

NOTE: All standard errors for continuous outcome models are based on the HC3 estimator
```

Appendix R: SPSS output of moderation analysis of the effect of Self-Reported Cognitive Functioning on Objective Cognitive Functioning using Repetitive Negative Thinking as a potential moderator.

```
Run MATRIX procedure:

************* PROCESS Procedure for SPSS Release 2.16.1 *****************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 1
    Y = SCF
    X = OCF
    M = PTQ

Sample size
         37

**************************************************************************
Outcome: SCF

Model Summary
          R       R-sq        MSE          F        df1        df2          p
      .7899      .6240    86.6667    16.8066     3.0000    33.0000      .0000

Model
             coeff         se          t          p       LLCI       ULCI
constant   41.5976     1.6361    25.4253      .0000    38.2689    44.9263
PTQ          .3782      .1211     3.1216      .0037      .1317      .6246
OCF         -.7718      .1389    -5.5551      .0000    -1.0544    -.4891
int_1        .0208      .0102     2.0507      .0483      .0002      .0415

Product terms key:

 int_1    OCF         X     PTQ

R-square increase due to interaction(s):
         R2-chng          F        df1        df2          p
int_1      .0494     4.2055     1.0000    33.0000      .0483

**************************************************************************

Conditional effect of X on Y at values of the moderator(s):
        PTQ     Effect         se          t          p       LLCI       ULCI
   -14.3620    -1.0709      .1618    -6.6183      .0000    -1.4001    -.7417
      .0000     -.7718      .1389    -5.5551      .0000    -1.0544    -.4891
    14.3620     -.4726      .2345    -2.0157      .0520     -.9497     .0044

Values for quantitative moderators are the mean and plus/minus one SD from mean.
Values for dichotomous moderators are the two values of the moderator.

********************* JOHNSON-NEYMAN TECHNIQUE ***************************

Moderator value(s) defining Johnson-Neyman significance region(s)
      Value    % below    % above
    14.2455    83.7838    16.2162

Conditional effect of X on Y at values of the moderator (M)
```

```
       PTQ     Effect         se          t          p       LLCI       ULCI
  -24.1081    -1.2739      .2347    -5.4275      .0000    -1.7514    -.7964
  -21.4081    -1.2177      .2124    -5.7326      .0000    -1.6498    -.7855
  -18.7081    -1.1614      .1914    -6.0666      .0000    -1.5509    -.7719
  -16.0081    -1.1052      .1723    -6.4141      .0000    -1.4557    -.7546
  -13.3081    -1.0489      .1557    -6.7387      .0000    -1.3656    -.7322
  -10.6081     -.9927      .1424    -6.9717      .0000    -1.2824    -.7030
   -7.9081     -.9365      .1335    -7.0143      .0000    -1.2081    -.6648
   -5.2081     -.8802      .1299    -6.7754      .0000    -1.1446    -.6159
   -2.5081     -.8240      .1320    -6.2403      .0000    -1.0926    -.5553
     .1919     -.7678      .1396    -5.4985      .0000    -1.0518    -.4837
    2.8919     -.7115      .1519    -4.6853      .0000    -1.0205    -.4025
    5.5919     -.6553      .1677    -3.9069      .0004     -.9965    -.3140
    8.2919     -.5990      .1863    -3.2156      .0029     -.9781    -.2200
   10.9919     -.5428      .2068    -2.6243      .0131     -.9636    -.1220
   13.6919     -.4866      .2288    -2.1263      .0410     -.9522    -.0210
   14.2455     -.4750      .2335    -2.0346      .0500     -.9501     .0000
   16.3919     -.4303      .2519    -1.7084      .0970     -.9428     .0822
   19.0919     -.3741      .2758    -1.3566      .1841     -.9351     .1869
   21.7919     -.3179      .3002    -1.0587      .2974     -.9287     .2930
   24.4919     -.2616      .3252     -.8046      .4268     -.9232     .3999
   27.1919     -.2054      .3505     -.5860      .5619     -.9185     .5077
   29.8919     -.1491      .3761     -.3966      .6942     -.9143     .6160

************************************************************************

Data for visualizing conditional effect of X on Y
Paste text below into a SPSS syntax window and execute to produce plot.

DATA LIST FREE/OCF PTQ SCF.
BEGIN DATA.

   -12.5172   -14.3620    49.5712
      .0000   -14.3620    36.1665
    12.5172   -14.3620    22.7619
   -12.5172      .0000    51.2579
      .0000      .0000    41.5976
    12.5172      .0000    31.9374
   -12.5172    14.3620    52.9445
      .0000    14.3620    47.0287
    12.5172    14.3620    41.1128

END DATA.
GRAPH/SCATTERPLOT=OCF WITH SCF BY PTQ.

****************** ANALYSIS NOTES AND WARNINGS *************************

Level of confidence for all confidence intervals in output:
    95.00

NOTE: The following variables were mean centered prior to analysis:
 OCF      PTQ

NOTE: All standard errors for continuous outcome models are based on the HC3 estimator

------ END MATRIX -----
```