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Enhancing Cognitive Outcomes in Paediatric Epilepsy: A Feasibility Study and Systematic Review

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Submitted in partial fulfilment of the requirements for the degree of
Doctorate in Clinical Psychology

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Chapter 1

Cognitive Training Programmes in Children with Epilepsy: A systematic review

Prepared in accordance with the author requirements for European Journal of Paediatric Neurology, <https://www.ejpn-journal.com/content/authorinfo>

Abstract

Objective

To explore what interventions have been used to aid cognition in paediatric epilepsy, including what cognitive areas they target, how cognition is assessed, and the efficacy compared to control groups.

Method

Studies were included if they included children under 18 years with a diagnosis of epilepsy who had undertaken an intervention to improve cognition either individually or in a group. Studies needed to have measured cognition before and after intervention and compared outcomes against waiting list or active control groups. MEDLINE, Embase, CINAHL and PsycINFO databases were last searched on 6th June 2025. All studies included were assessed using the QualSyst tool (Kmet et al., 2004) and the results were synthesized using narrative methods (Cherry et al., 2023)

Results

Six studies were included, with a total of 229 participants: one randomised controlled trial, four non-randomised controlled trials and a feasibility study. Two were rated as methodologically strong. Four interventions used computer-based tasks, and three used paper or construction-based tasks. All included coach/therapist input. The studies targeted a range of cognitive domains, and there was significant heterogeneity in outcome measurement, limiting generalisability. Overall, the evidence for the effectiveness of cognitive training in children with epilepsy was limited.

Discussion

Overall, there was limited evidence for cognitive rehabilitation to improve working memory, attention, executive functioning and short-term memory, so no interventions can be recommended at this time. Studies were heterogenous and had methodological flaws (e.g. small samples and unclear outcome measure validity). Future studies might consider multi-centre collaboration using a standardised outcome protocol. Given the high rates of cognitive impairment in young people with epilepsy, and its impacts on learning and development, it is important to establish effective means of intervention.

Funding

No specific funding was used.

Registration

This review was registered on Prospero: CRD42024526828

Introduction

Background and prevalence

Childhood epilepsies are a heterogeneous group of disorders with an incidence of approximately 1 in 418 children in Scotland (Symonds et al, 2021), and slightly less in America at 44.5 in 100,000 (Wirrell et al., 2012). The International League Against Epilepsy define three diagnostic levels: seizure type; epilepsy type; and epilepsy syndrome. Some syndromes have subtle impacts on cognition, such as Idiopathic or Genetic Generalised Epilepsy (IGE/GGE), which include absence and myoclonic seizure activity with a genetic aetiology. Other syndromes, such as Developmental and Epileptic Encephalopathies (DEE), are rare and severe epilepsies that lead to cognitive and behavioural difficulties (Scheffer et al., 2017).

Impact of Epilepsy on Cognition

In a review exploring cognition and GGE, Ratcliffe et al. (2020) found that individuals with GGE have impaired semantic knowledge, attention, executive functions (EFs) and processing speed, despite having 'average' IQ. Cheng et al. (2017) performed a case-control study and found that absence epilepsy was associated with difficulties in visual attention, but those with benign epilepsy performed significantly worse than healthy controls on spatial tasks. Additionally, those with IGE show difficulties in long-term retrieval of verbal and non-verbal information compared to normally developing peers, despite normal encoding and short-term retrieval, which is described as accelerated forgetting (Davidson et al., 2007; Joplin et al 2020). These studies highlight the heterogeneous impact epilepsy has on the cognition of young people, and therefore the complexity clinicians face when trying to improve patients' cognitive and daily functioning. Cognitive deficits in epilepsy have been linked to deficits in

academic performance (Ibekwe et al., 2007), as well as poor quality of life and elevated levels of anxiety (Reilly et al., 2015). This highlights the need for research exploring how to improve learning and attainment in this population.

Several variables may lead to the cognitive deficits seen in GGE. Ratcliffe et al. (2020) highlight that individuals with GGE have structural and functional abnormalities in fronto-cortico-thalamic connections and the default-mode network. These have been linked to cognitive deficits, such as poor working memory (WM), poor cognitive flexibility and slower processing speed. A longitudinal study conducted by Lin et al. (2014) found that children with Juvenile Myoclonic Epilepsy (JME) had lower IQ and inhibition scores compared to peers 2 years post diagnosis. Children with JME and lower cognitive test scores had higher cortical volume and thickness in fronto-parieto-temporal regions, which suggests they may have less synaptic pruning compared to typically developing peers. GGE has been linked to several deficits in ion channelopathy in the brain, leading to seizure activity and cognitive deficits (Ng et al., 2024). Anti-seizure medication (ASM) is used to modify and manage the release of ions in the brain to reduce seizure activity.

There is mixed evidence regarding the impact of ASM on cognition in children with epilepsy. A systematic review by Besag and Vasey (2021) found that some ASMs, such as phenobarbital, have been associated with cognitive impairments, including memory; however, others, such as lamotrigine, improve problem-solving abilities. It may be that high doses of ASM have a neurotoxic effect; however, research also suggests that early use of ASM can prevent more serious epilepsies, such as DEE, even if ion channels are still dysfunctional (Marguet et al., 2015). Therefore, early use of ASM may have a positive, cognitive preserving effect. Additionally, in a study comparing the impact of interictal

epileptiform discharges (IEDs) and ASMs on a set-shifting task, Warsi et al. (2023) found that children who had more IEDs had poorer performance. Medication helped to control IEDs and therefore preserve cognitive performance. However, this study had a small sample size, so results must be interpreted with caution. Due to the multiple cognitive domains impacted by paediatric epilepsy, as well as the multitude of factors that may impact cognition, including seizures and medication, it is important to develop and evaluate interventions aimed at improving cognition, and determine if improvements are maintained over time.

Interventions to Improve Cognition

Interventions to improve cognition (IIC) can be defined as: “Any intervention which intends to enable clients and their families to live with, manage, by-pass, reduce or come to terms with cognitive deficits” (Wilson, 1989). IIC have been developed for a range of cognitive deficits, including attention, memory and EF (Langenbahn et al., 2013). Research has focused on adult populations who have experienced acquired or traumatic brain injury; however, there is a growing literature focusing on IIC in children with a range of neurological and/or neurodevelopmental conditions. There are several types of IIC, including: cognitive training, which involves repeating cognitive tasks to improve areas of deficit; compensatory strategies, including the application of problem solving frameworks and other metacognitive strategies, often alongside external aids such as prompting or alarms (Bayley et al., 2023); and holistic approaches, which involves creating a safe, therapeutic environment in which a patient can develop their intact abilities and learn new skills to enhance daily functioning (Ben-Yishay & Diller, 2011). Limond et al. (2014) highlight a paediatric neurocognitive framework that may be used for childhood acquired brain

injuries, which argues that IIC must start by building psychosocial foundations, before teaching compensatory strategies and training areas of cognition. This is due to children needing support to implement strategies, as well as having cognitive resources to focus on strategies rather than wider systemic and lifestyle factors. IIC need to align with the child's development, and strategies may have to be revisited once other areas of cognition have developed. An example of this model in practice is Epilepsy Journey, a computer-based intervention focused on improving EF and key psychosocial issues children with epilepsy might experience, such as sleep and stress (Glaser et al., 2017). The pilot study has shown improvements in the quality of life of children with epilepsy (Modi et al., 2021). There are other psychosocial issues that are seen in many individuals with epilepsy, including comorbid mental health difficulties (Dagar & Falcone, 2020), which may impact their ability to engage in IIC. Children with epilepsy are also more likely to experience social deprivation than those without epilepsy (Mula & Sanders, 2016), which may need to be addressed before IIC begin.

Karch et al. (2013) performed a meta-analysis to explore the impact of IIC in children with acquired brain injuries, attention deficit hyperactivity disorder (ADHD), specific learning disorders, and 'typically developing' children. They found the impact of programmes on attention and EF was minimal compared to waiting list controls. The impact on memory, which included WM, short and long-term memory, showed a mean difference in standard deviations of 0.65 compared to controls, which was higher than other areas of cognition; however, the 95% confidence interval crossed zero. The authors concluded, therefore, that IIC were not useful in improving children's cognition. However, many of the studies reviewed targeted single domains, and did not consider stage of development or

psychosocial factors, which could be why they have limited utility (Limond et al., 2014).

There is still debate regarding the utility of IIC, with systematic reviews consistently highlighting the limits of WM interventions, as the skills learnt do not generalise beyond tasks highly similar to those used in training, and they have limited long-term impact (Melby-Lervåg & Hulme, 2013; Bharadwaj et al., 2022).

Cubillo et al. (2023) provided cognitive training to 28 typically developing children to evaluate the effects using fMRI. They found that WM training has an immediate impact on WM measures and attention. This was sustained for a Go/No Go task, which was a measure of generalisation, eight months later. Improvements were linked to increased activation in the fronto-striatal-thalamic systems in the brain. However, due to the small sample size, it is hard to draw robust conclusions from this study, including regarding the generalisability of its findings. Additionally, in an RCT including 98 children with Fragile X syndrome, Scott et al. (2020) found that WM training improved outcomes on WM assessments, as well as reduced attention deficit behaviours as reported by caregivers. However, as these children had a lower average IQ than the general population (64), it is hard to draw generalisations to individuals within a 'normal' IQ range. Further research and reviews are therefore required due to conflicting evidence from these studies.

Current Review

We aimed to systematically review the evidence for the use of IIC in a paediatric epilepsy population with a view to making recommendations to inform future research and clinical practice.

The questions for this review were as follows¹:

- What interventions have been used to aid cognition in paediatric epilepsy?
- What areas of cognition do interventions target in paediatric epilepsy?
- What measures are used to assess outcomes of IIC in paediatric epilepsy?
- What are the impacts of IIC on cognitive functioning in paediatric epilepsy?

Method

This review was conducted in accordance with the PRISMA 2020 guidelines. A completed checklist for the review is provided in Appendix 3, and a separate abstract checklist in Appendix 4.

Eligibility Criteria

Inclusion Criteria:

- Participants under the age of 18 with a primary diagnosis of epilepsy.
- Studies using IIC targeting at least one area of cognition, including memory, attention, EF etc. Studies that included IIC as part of a multi-component intervention were also included.
- Studies must have reported on pre- and post-treatment measures of cognition.
- Interventions delivered on both a one-to-one and group setting.

¹ A review question on the impact of intervention on quality of life was planned but as no studies addressed this, it is not considered further.

- Studies must have included either a waiting list/treatment as usual control group or an active control condition.
- Relevant study designs included Randomised Control Trials, Controlled Clinical Trials, pilot studies and Single Case Experimental Designs.
- Studies must have been published in a peer-reviewed journal, in English.

Exclusion Criteria:

- Participants with structural, traumatic or infectious causes for epilepsy.
- Studies looking at exclusively mental health or physical health interventions, or pharmaceutical interventions alone.

Information Sources

Four databases [MEDLINE, Embase, CINAHL, PsycINFO] were searched using terms combining: epilepsy/seizures; children/adolescents; areas of cognition; and rehabilitation/remediation (refer to Appendix 1 for full details). The last searches were conducted on 6th June 2025. No date ranges were applied, and age filters were not applied as age was addressed through the inclusion criteria. Forward and backward chaining was completed using the final included studies. The review was registered on PROSPERO on 19th April 2024 (registration number CRD42024526828; please see for full protocol and amendments).

Selection Process

Two researchers independently reviewed titles and abstracts of 10% of the records obtained (n=614). They disagreed regarding 20 papers. Reviewers met to clarify inclusion and

exclusion criteria, which led to these disagreements being resolved. The first author then completed the remaining 90% of the title and abstract screening.

The researchers also independently reviewed 10 full text records and disagreed regarding 2 papers. One had both children and adult participants, and did not report the results for child participants separately, so was eventually excluded. The other was a cognitive behavioural intervention that did not target improving an area of cognition. The first author reviewed the remaining 59 full text records.

Data Collection

A data extraction table was designed based on Corrigan et al. (2016), and two researchers used this to independently extract data from all six eligible studies. Extracted data were compared, with any discrepancies being resolved through discussion. When information was unclear, such as type of epilepsy, authors of the eligible studies were contacted to provide further information.

Data were collected regarding:

- Author, year, and source of publication.
- Study design information: type of methodology, timepoints of data collection.
- Participant characteristics: number of participants, age, gender split, and estimated or actual intellectual ability.
- Epilepsy characteristics: type of epilepsy, treatments, length of time with diagnosis, and how controlled their epilepsy currently is.
- The intervention: area(s) of cognition targeted, format, and length of training.
- Control condition: format and how much contact time they received.

- Outcomes: Measures of domain-specific cognitive functions, recorded at each measurement time point e.g. baseline and follow-up data.

Risk of Bias Assessment

The QualSyst tool (Kmet et al., 2004) was used to assess for risk of bias. This tool provides a comprehensive review of studies regardless of methodology. It also has good inter-rater reliability (0.76-0.80). Two researchers completed this independently for all six studies.

Effect Measures

We planned to analyse the outcomes on domain-specific cognitive assessments by using the effect sizes already provided in the reports, or to calculate the most appropriate effect size from the data, for between-subjects outcomes. The focus was on post-intervention outcomes, but follow-up outcomes were considered if provided. Meta-analysis was considered as a method of data synthesis and if this was not possible a narrative synthesis was planned instead. Due to the variation in study design, intervention type, and cognitive domain targeted, the narrative synthesis approach was preferred.

Synthesis Methods

To determine which reports would be eligible for inclusion in the synthesis, they were compared to the inclusion and exclusion criteria. Meta-analyses could not be undertaken due to the heterogeneity of the interventions and outcome measures; hence, no sensitivity analyses were required. Therefore, data were presented in a table format, with a narrative synthesis of findings, following the guidance of Cherry et al. (2023). Data conversions were completed for studies that did not provide effect sizes but the data available to calculate these.

Results

Study Selection

The search and selection process are presented in Figure 1. A random sample of 10% (614/6142) of the records that were title and abstract screened for inclusion in full text review were also independently rated by a second rater to determine inter-rater reliability. The second reviewer disagreed with 3% of the records reviewed. In practice, this related to 20 incidences of disagreement, which were resolved through discussion. Many papers included medical interventions, rather than psychological. Extra care was taken when reviewing these records to ensure that studies that may include medical and psychological interventions were included. If papers did not include enough information to make a

definitive decision, they moved to full text screening.

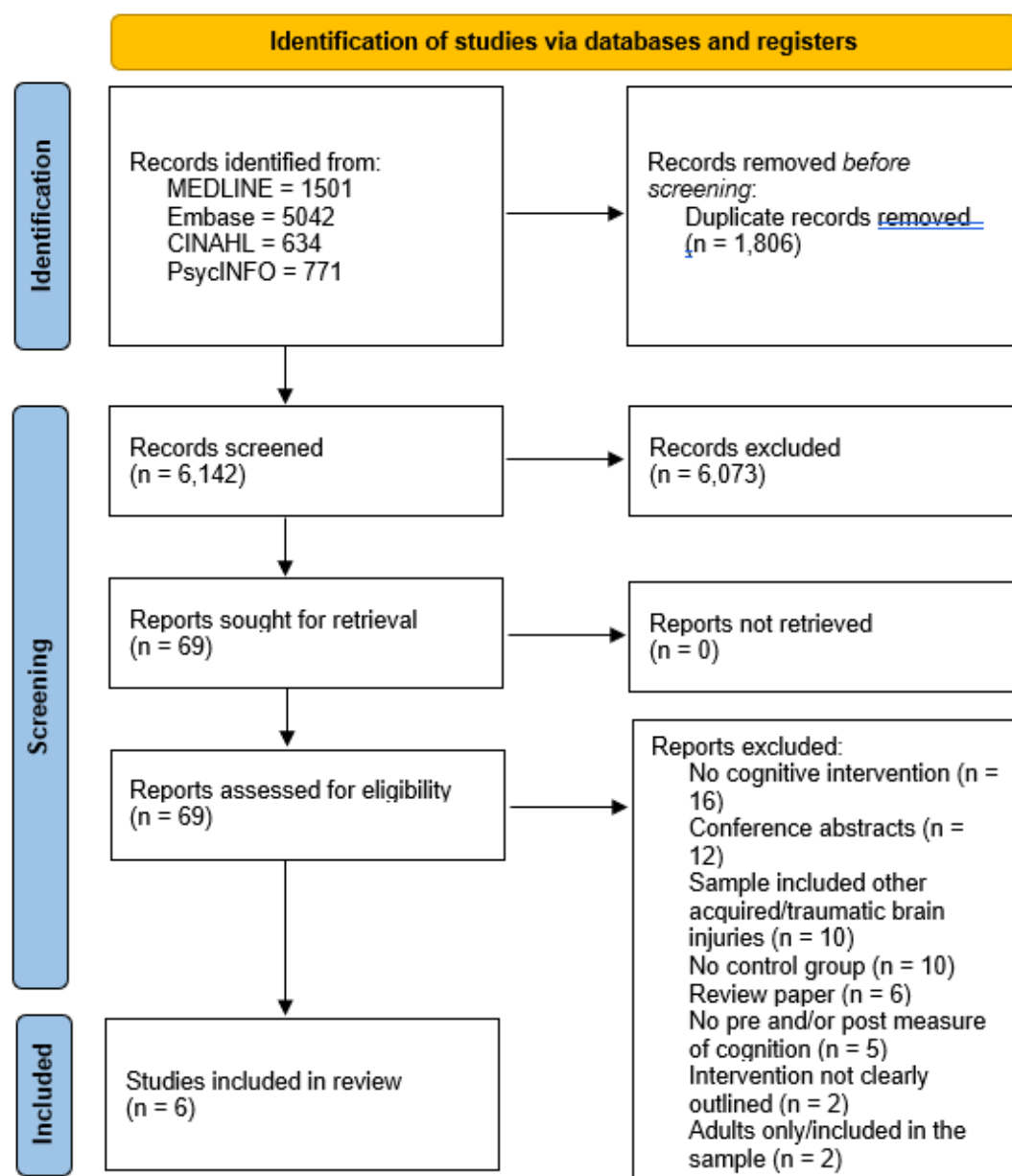


Figure 1. PRISMA Flow Diagram

Study Characteristics

A summary of the six studies included in the present review are shown in Table 1.

Table 1. Summary of the six included studies.

Reference	Sample		Epilepsy information	Design	Intervention Target and Delivery	Outcome Measure(s)	Analysis	Main findings	Qualsyst Rating
	Intervention	Control							
Kerr and Blackwell (2015)	42 children. Mean age (years with decimal): 11.1 (SD = 3). 24 males, 18 females. Mean IQ: 94.1 (SD = 12.8) N = 11 had comorbid diagnoses (ADHD, anxiety, ASD).	35 children. Mean age: 10.6 (SD = 2.7). 16 males, 19 females. Mean IQ: 88.8* (SD = 9.9) N = 10 had comorbid diagnoses.	65.7% generalised epilepsy; 20% partial seizures; 14.3% both. Participants had diagnosis for ≥ 6 months, all were medicated. 23 had daily seizures; 13 weekly; 11 monthly; 15 every few months; 15 had no seizure pattern.	Randomised clinical trial – 2 arms with waiting list control. Outcomes measured at baseline and post intervention.	Aspects of WM trained using Cogmed "RoboMemo" computer programme. This contained 12 exercises with difficulty titrated to performance. Training was supervised by parents 5 times per week over 5-7 weeks, with weekly check-ins from a psychologist.	DRF, DRB, LR and CR from the WMTB-C. SSPF, SSPB, and VDS from the WISC-IV. CC from the TEA-CH. ACT	MANCOVAs for near-transfer effects (nine outcomes), far-transfer effects (three outcomes), and parental reports (three outcomes)	When controlling for IQ and baseline scores, statistically significant near-transfer improvements were found between groups, with large effect sizes in DRB (Cohen's $d = 0.95$), CR (Cohen's $d = 0.80$), and SSPF (Cohen's $d = 0.76$). No significant changes in other outcome measures, nor in parental reports.	High
Khaleghi et al. (2024)	45 children assigned to one of three groups (computer rehabilitation, task-oriented		Data not provided on epilepsy type or	Non-randomised controlled trial.	Computer-based group completed the spatial WM and attention shift	IVA2	ANCOVAs compared post-test and follow-	Computer and task-oriented groups had significantly improved IVA2 scores post-	Acceptable

	rehabilitation, waiting list, n = 15 each). Demographics not reported per group, but whole sample was aged 6-12 years, with IQ 85-109. Attention scores were 1 SD below population mean.	duration since diagnosis.	All participants medicated and had controlled seizures.	Outcomes measured at baseline, post intervention and follow-up (time period not provided).	tests from CANTAB once a week over 12 weeks. Task-oriented group completed 12 weekly, hour long, psychologist-led sessions of paper-and-pencil sustained attention tasks.	up attention scores.	intervention (Cohen's d = 0.970) and at follow-up (Cohen's d = 0.964) compared to the control group.		
Saard et al. (2019)	17 children. Mean age: 9.95 (SD = 1.212).**	22 children. Mean age: 10.29 (SD = 1.850).	Focal epilepsy. All participants were medicated and had controlled seizures. Length of diagnosis ranged from 0 to 11 years.	Non-randomised controlled trial. Outcomes measured at baseline, post intervention and 1.31-year follow-up. 10 intervention and 9 control children completed follow up.	Visuospatial functions were trained using the FORAMENRehab Cognitive Rehabilitation Visuospatial module. This comprises of seven computer illustrated animation exercises. Children completed sessions twice a week for five weeks with a therapist.	Outcomes on each task, including solving and/or reaction time, number of correct responses, and mistakes.	Wilcoxon signed-rank test	No between-group analyses were conducted. Data not provided to calculate effect sizes. The training group had a significant improvement in visual organisation, visual attention and correct answers in visuospatial perception. There was no significant improvement in visual recognition. The waiting list group showed an improvement in a test of visuospatial perception. They showed no significant improvements in other areas.	Limited

Saard et al. (2017)	17 children. Mean age: 9.95 (SD = 1.212).**	12 children. Mean age: 10.29 (SD = 1.850).	Focal epilepsy. All participants were medicated and had controlled seizures. Length of diagnosis ranged from 0 to 11 years.	Non-randomised controlled trial. Outcomes measured at baseline, post intervention and 1.31-year follow-up. 10 intervention and 9 control children completed follow up.	Attention was trained using the FORAMENRehab Cognitive Rehabilitation Attention module. This comprises of four computer illustrated animation exercises. Children completed sessions twice a week for five weeks with a therapist.	Outcomes on each task, including solving and/or reaction time, number of correct responses, and mistakes.	Wilcoxon signed-rank test	Data not provided to calculate effect sizes. The intervention group showed significantly improved complex attention in some tasks, but not others, and improvements in tracking tasks relative to control. No significant improvements seen in any other tasks relative to control.	Limited
Schaffer et al. (2017)	33 children with epilepsy. Mean age: 10.88 (SD = 1.52). 16 males, 17 females. Estimated IQ (z score) = -0.85 (SD = 0.84). 6 had ADHD. 4 had learning deficits.	27 healthy controls. Mean age: 10.18 (SD = 1.40). 13 males, 14 females. Estimated IQ = 0.16 (SD = 0.93).	18 self-limited epilepsy, 15 GGE. 75% took one medication; 25% took two. All had controlled seizures. Mean length of time with diagnosis:	Quasi-experimental feasibility study. Outcomes measured at baseline and post intervention.	Memory training aimed to improve organisation and memory skills, e.g. using mnemonics. Children completed two 5-week modules: memory skills and psychosocial skills.	11 memory measures from the TOMAL. CMS immediate and delayed memory. RAVLT Immediate and delayed. RCFT. Cancellation and number	Repeated measures ANOVAs and Chi-Square analyses with odd ratios for risk.	Auditory and visual memory improved after intervention relative to controls ($\eta^2 = 0.259$). No interaction reported between memory modality and intervention. Overall memory, which includes short-, long-term and WM, improved after intervention relative to controls ($\eta^2 = 0.492$). Post hoc tests showed significant improvements in short-term memory ($\eta^2 = 0.261$).	High

			4.53 years (SD = 2.46)			cancelling from the WISC-IV.		There was a non- significant trend towards an interaction between memory system and intervention ($p = 0.06$, $\eta^2 = 0.261$). A significant proportion of children with epilepsy went from having deficit AVM scores to scores within the normal range (Cramér's $V = 0.268$).	
Zaldumbide- Alcocer et al. (2024)	12 children. Median age: 9.5 (range = 8-12.5). 7 males, 5 females.	10 children. Median age: 12 (range = 10-15). 4 males, 6 females.	55% focal epilepsy; 9% generalised epilepsy; 31% mixed. 55% structural aetiology; 9% genetic aetiology; 31% unknown aetiology. 95% were medicated.	Non- randomised controlled trial. Outcomes measured at baseline and post intervention.	Intervention targeted EF through 7-18 1:1 sessions of LEGO- based therapy with a neuropsychologist. Tasks included building Lego sets and programming robotics kits, with increasing complexity over sessions.	NEUROPSI and BANFE- 2.	ANCOVA and Wilcoxon rank sum test.	Data not provided to calculate effect sizes. Intervention group showed statistically significant improvements in OMC, APC and DLC indices of BANFE-2 relative to controls. No significant difference in overall EF scores between groups post-intervention. Lego group showed significant gains on memory and OMC indices compared to controls. No other significant between groups differences post- intervention. No significant differences in on NEUROPSI between groups post-intervention.	Acceptable

* This is a significant difference from the control group.

** These intervention group participants are the same.

IQ = Intelligence Quotient, SD = Standard Deviation, ADHD = Attention Deficit Hyperactivity Disorder, ASD = Autism Spectrum Disorder, WM = Working Memory, DRF = Digit Recall Forward, DRB = Digit Recall Backward, LR = Listening Recall, CR = Counting Recall, WMTB- C = Working Memory Test Battery for Children; SSPF = Spatial Span Forward; SSPB = Spatial Span Backwards; VDS = Visual Digit Span, WISC-IV = Weschler Intelligence Scale for Children Fourth Edition, CC = Creature Counting, TEA-CH = Test of Everyday Attention for Children, ACT = Attention Capacity Test, CANTAB = Cambridge Neuropsychological Test Automated Battery, IVA2 = Integrated Visual and Auditory Continuous Performance Test, TOMAL = Test of Memory and Learning, CMS = Children's Memory Scale, RAVLT = Rey Auditory Verbal Learning test, RCFT = Rey Complex Figure test, AVM = auditory verbal memory, NEUROPSI = Neuropsychological Attention and Memory Battery, BANFE-2 = Neuropsychological Battery of Executive Functions, OMC = orbitomedial cortex, APC = anterior prefrontal cortex, DLC = dorsolateral cortex

Quality appraisal

The intra class correlation for the two reviewers' QualSyst ratings was 0.72, indicating good reliability. Within this, there were 14 disagreements at the item level (for full ratings, please see Appendix 2). Using definitions described by Lee et al. (2008), two studies were rated as high quality (Kerr & Blackwell, 2015; Schaffer et al. 2017); two were rated as acceptable (Khaleghi et al. 2024; Zaldumbide-Alcocer et al., 2024); and two were rated as limited (Saard et al., 2017, 2019).

Of the two high quality studies, one was a randomised controlled trial (RCT; Kerr & Blackwell, 2015), whereas the other was a quasi-experimental feasibility study (Schaffer et al., 2017). Both studies used convenience samples recruited through hospitals. Schaffer et al. (2017) blinded the investigators, whereas Kerr and Blackwell (2015) reported that blinding was not possible, as the person administering the cognitive assessment was serving as the intervention coach. Schaffer et al. (2017) did not report confidence intervals for the results of post-hoc tests following ANOVA, or for the Chi-square analysis. Schaffer et al. (2017) controlled for IQ as part of the ANOVA, but did not report any other confounding variables.

Of the two studies rated as acceptable, both used a non-randomised controlled trial. Khaleghi et al. (2024) was limited in its description of participant characteristics, including type of epilepsy and length of time with diagnosis. Both studies utilised a convenience sample. Khaleghi et al (2024) mentioned random allocation but gave no details of the method for this. Zaldumbide-Alcocer et al. (2024) did not randomly allocate participants; rather, participants were allocated according to their expressed

preference. They also reported blinding, but did not report who was blinded. Neither study mentioned confounding variables.

The two studies rated as poor (Saard et al., 2017, 2019) are non-randomised controlled trials. They included an intervention, waiting list control and healthy control group; however, the groups were only compared on the initial assessment. Additionally, Saard et al. (2019) did not compare the intervention and waiting list control groups after the intervention, making it hard to comment on the effectiveness of the intervention. Both studies did not use validated, standardised outcome measures, and some key information such as statistical results were not reported.

Synthesis

General Overview of Studies

All studies required a diagnosis of epilepsy for participation. However, the characteristics of the samples varied in their presentation due to differences in inclusion and exclusion criteria relating to length of time with diagnosis and how well controlled seizure activity was. Two studies required 6 months or more with the diagnosis (Kerr & Blackwell, 2015; Schaffer et al., 2017), whereas two used participants with newly diagnosed epilepsy (Saard et al., 2017, 2019), and one did not stipulate a length of diagnosis (Zaldumbide-Alcocer et al., 2024). All studies apart from Kerr and Blackwell (2015) used participants with good seizure control. Inclusion and exclusion criteria also differed in relation to cognitive ability. Kerr and Blackwell (2015) were explicit regarding excluding participants with an IQ of >70. Saard et al. (2017) and Saard et al. (2019) were less definitive, excluding participants with “mental

retardation". Zaldumbide-Alcocer et al. (2024) was also unclear regarding inclusion criteria, indicating that participants had to have "cognitive deficits associated with epilepsy". Khaleghi et al. (2024) included participants with IQ scores of 85-109, but did not specify a rationale. Schaffer et al. (2017) had a cut-off of >79, but did not report the rationale. Overall, some studies have concerns about the applicability of interventions for people whose general ability falls more than a single SD below the mean, but all agree that those falling two SDs below the mean would not be able to engage in interventions. With IQ impairments seen in 7-40% of children with epilepsy (Moorhouse et al., 2020), this may exclude a large proportion of children who need support. No study reported use of power calculations in planning its sample size. The sample sizes were variable, ranging from 22 to 77 including intervention and control groups.

In terms of the intervention components, four studies used computerised cognitive rehabilitation programmes (Kerr & Blackwell, 2015; Khaleghi et al., 2024; Saard et al., 2017; 2019). Two studies used paper-and-pencil rehabilitation (Khaleghi et al., 2024; Schaffer et al., 2017) and one used assembly of Lego and robotic programming (Zaldumbide-Alcocer et al., 2024). All the interventions were run by a therapist/psychologist, but not all studies reported their qualifications. In five studies, the therapists had an active role in delivering the therapy (Khaleghi et al., 2024; Saard et al., 2017; 2019; Schaffer et al., 2017; Zaldumbide-Alcocer et al., 2024). Kerr and Blackwell (2015) provided weekly check ins, with participants and their parents completed the intervention with minimal input.

The amount of training provided differed between studies, with the overall ‘dose’ ranging from 6 to 26.25 hours of intervention (see Table 2). Individual sessions ranged from 30-120 minutes in duration, with most lasting 30-60 minutes. Most involved 1-2 sessions per week for 2-3 months. However, the Kerr and Blackwell (2015) intervention was more intensive, stipulating five parent-guided sessions per week (though 10% did not complete the minimum 25 sessions). Zaldumbide-Alcocer et al. (2024) had a large range in the number of sessions offered (7-18), with no rationale for this variation provided.

Table 2 – Duration and dose of interventions in included studies.

Study	Sessions per week	Session duration (minutes)	Weeks spent in intervention	Overall intervention dose (hours)
Kerr and Blackwell (2015)	5	30-40	5-7	12.5-26.25
Khaleghi et al. (2024)	1	45 (computerised)/60 (paper and pencil)	12	9/12
Saard et al. (2019)	2	40	6	8
Saard et al. (2017)	2	30-40	6	6-8
Schaffer et al. (2017)	1	120	5	10
Zaldumbide-Alcocer et al. (2024)	1	60	7-18	7-18

Studies Targeting Memory

Two high quality studies (Kerr & Blackwell, 2015; Schaffer et al., 2017) targeted memory with their intervention. Kerr and Blackwell (2015) targeted WM, whereas Schaffer et al. (2017) targeted auditory short-term memory. Kerr and Blackwell (2015)

utilised the Cogmed “RoboMemo” programme (Klingberg et al., 2005). This includes a range of exercises presented on a computer, where children must hold information in mind and often manipulate it over a brief period of time. Schaffer et al. (2017) utilised a memory intervention outlined by Schaffer and Geva (2016). This includes teaching young people a range of internal and external memory strategies and relating these to their daily life, such as using visualisation or association. Both studies used validated and standardised measures of auditory and visual WM, including Digit Span Backwards. Kerr and Blackwell (2015) also included a validated and standardised measure of attentional control and switching. Schaffer et al. (2017) included validated and standardised measures of auditory and visual short-and-long-term memory.

Kerr and Blackwell (2015) provided effect sizes for their main findings. Schaffer et al. (2017) reported effect sizes for some findings, and the rest could be calculated from the information provided. Kerr & Blackwell (2015) found a significant improvement in one measure of auditory WM (Digit Span Backwards; large effect size) and one measure of visual-verbal WM (Counting Recall; large effect size) following the intervention. There was also a transfer effect to visual attention span (medium effect size). However, other measures of auditory WM (Listening Recall) and visual-verbal WM (Visual Digit Span and Creature counting) showed no significant improvements. Similarly, there were no significant changes on measures of immediate auditory attention, visual WM and processing complex auditory input. Additionally, parents did not report any significant reduction in ADHD symptoms, highlighting limited effectiveness and generalisability.

Schaffer et al. (2017) found a significant improvement in children with epilepsy's auditory and visual memory following the intervention (large effect sizes). Additionally, there was a significant improvement in overall memory following the intervention (large effect size); however, post-hoc tests only showed a significant improvement in short-term memory (large effect size). Of note, there was a near-significant interaction between intervention and memory system (large effect size). Additionally, a significant proportion of children with epilepsy went from having auditory WM scores in the deficit range to the normal range following the intervention (small effect size).

Studies Targeting Attention

One acceptable quality study (Khaleghi et al., 2024) and one limited study (Saard et al., 2017) targeted attention with their intervention. Khaleghi et al. (2024) used two different interventions: the spatial WM and attention shift subscales from the computerised cognitive rehabilitation program of the Cambridge Neuropsychological Test Automated Battery (Robbins & Sahakian, 1983); and paper-and-pencil cognitive rehabilitation, which focused on WM, attention and inhibition. To measure changes in attention, they used the Integrated Visual and Auditory Continuous Performance Test, which measure a child's ability to maintain focus and react to stimuli over a period of time. Saard et al. (2017) used the FORAMENRehab software to measure cognition and deliver the intervention. This was initially developed for use in adult stroke and traumatic brain injury patients (Sarajuuri & Koskinen, 2006), rather than children with acquired brain injuries. The authors did not mention if the software had been adapted for children, and was therefore appropriate for use.

Effect sizes were calculated for Khaleghi et al. (2024) based on the information provided for between-subjects findings. There were significant improvements in attention for both the computer and task-based cognitive rehabilitation groups compared to the control group (large effect size). Saard et al. (2017) did not provide effect sizes, or the data needed to calculate this. They reported that, compared to the waiting list control group, children with epilepsy significantly improved performance on some tasks of complex attention and tracking, but not others.

Studies Targeting Executive Functioning

One acceptable study targeted EF (Zaldumbide-Alcocer et al., 2024), including WM, inhibitory control, and planning. They used a Lego-based therapy intervention (Espinosa-Garamendi et al., 2022). This involves young people building Lego sets and programming robotic Lego with increasing complexity over sessions. Zaldumbide-Alcocer et al. (2024) used the NEUROPSI and BANFE-2 to measure cognition. The NEUROPSI is a neuropsychological assessment developed and validated in a Mexican population, which measures various areas of cognition including memory, attention and EF. The BANFE-2 is an assessment tool that measures various EFs, including inhibitory control, metamemory, and visuospatial WM, that was developed and validated with a Mexican population. Data was not provided to calculate effect sizes. There were significant improvements for EF indices as measured by the BANFE-2, but not overall EF score or NEUROPSI scores, compared to the control group. Transfer effects were also found for memory but not other areas of cognition such as attention.

Studies Targeting Visuospatial Functions

One limited study targeted visuospatial functions (Saard et al., 2019) and will therefore be described in limited detail. This study used the FORAMENRehab software, which is described above, to measure cognition and deliver the intervention. No effect sizes were reported, nor was there sufficient information provided to enable independent calculation of these. Performance of the intervention and waiting list control groups was not compared. Nevertheless, it was reported that the intervention group showed significant improvements in visual organisation, visual attention and some measures of visual perception, but not visual recognition. The waiting list group showed significant improvements in visuospatial perception reaction time but no other areas.

Discussion

Summary of Results

This review did not find compelling evidence for the current range of cognitive training interventions used in children with epilepsy (see Table 3). Interventions targeted a range of cognitive domains, including WM, short- and long-term memory, attention, EF and visuospatial. Four studies used validated and normed neuropsychological assessments (Kerr & Blackwell, 2015; Khaleghi et al., 2024; Schaffer et al., 2017; Zaldumbide-Alcocer et al., 2024), whereas two used tasks from the FORMENRehab software (Saard et al. 2017; 2019), which have not been validated and normed on a child population.

Table 3. Results of intervention by cognitive domain

Cognitive Domain	Study	Direction of effect
Memory	Kerr & Blackwell (2015)	Some WM scores in the intervention group increased, others did not, compared to controls
	Schaffer et al. (2017)	Auditory, visual and short-term memory improved in the intervention group compared to controls
	Zaldumbide-Alcocer et al. (2024)	Gains in memory were seen in the intervention group compared to controls
Attention	Kerr & Blackwell (2015)	Some visual attention scores in the intervention group increased, others did not, compared to controls
	Khaleghi et al. (2024)	Attention scores for the intervention groups significantly improved compared to controls
	Saard et al. (2017)	Some attention scores increased in the intervention group, others did not, compared to controls
	Zaldumbide-Alcocer et al. (2024)	Attention did not improve compared to controls
Executive Functioning	Zaldumbide-Alcocer et al. (2024)	Some areas of EF improved follow intervention, others did not, compared to controls
Visuo-spatial	Saard et al. (2019)	No direct comparison of intervention and control group conducted

WM = working memory; EF = executive functioning

The findings are most encouraging regarding memory intervention (broadly defined), but still lack methodological rigour. Improvements were reported in auditory WM (Kerr & Blackwell, 2015; Schaffer et al., 2017); visual-verbal WM (Kerr & Blackwell, 2015); auditory and visual short-term memory (Schaffer et al., 2017); and overall memory (Zaldumbide-Alcocer et al., 2024). However, these studies had limited

follow-up periods, so it cannot be concluded that these changes are maintained over time. Additionally, Kerr & Blackwell (2015) did not find improvements in all measures of WM. Therefore, effects of training programmes may be selective. These results are similar to the wider cognitive rehabilitation literature, as there is inconclusive evidence on the generalisability of training effects. This may be due to the measures used: some measures, such as digit span backwards, may better capture improvements in WM compared to listening recall. Additionally, some tasks may require other cognitive resources to complete, which may not be as developed in some children. For example, listening recall requires a good understanding of spoken language, whereas digit span backwards only requires number knowledge. Everyday memory interventions in children with acquired brain injuries and adults with epilepsy also show promising improvements (Ho et al., 2011; Radford et al. 2011). Nevertheless, many of the studies have small sample sizes or are pilot studies. Further, large scale RCTs are needed to increase certainty in improvements in memory domains in children with epilepsy.

Three studies also showed improvements in attention (Kerr & Blackwell, 2015; Khaleghi et al., 2024; Saard et al., 2017). Saard et al. (2017) reported improvements in complex attention and tracking. However, follow up data was not reported, so it cannot be concluded that these improvements were sustained. Khaleghi et al. (2024) reported improvements in overall attention, but did not provide data on improvements in auditory vs visual attention. Kerr & Blackwell (2015) did not target attention with their intervention but reported improvements in visual attention span following a WM intervention. Zaldumbide-Alcocer et al. (2024) did not find any

significant improvements in attention following an EF intervention, highlighting that not all training interventions may generalise to wider cognition. Due to the limited nature of data, including sample sizes and reported statistical analyses, additional research is needed to better understand whether IICs can improve attention. These results are more positive than those found in other studies; for example, a systematic review by Karch et al. (2013) found that 11 studies targeting attention in children with and without ADHD showed low overall improvements compared to controls. Children with epilepsy do not significantly differ on neuropsychological measures of attention compared to 'typically developing children'; however, parents report that children with epilepsy have more difficulties with 'everyday attention' compared to controls (Gascoigne et al., 2017). When assessing the effectiveness of IICs, studies must consider generalisation of improvements outside of neuropsychological measures, as we cannot assume that training related gains in underlying functions will translate into improved everyday task performance. Further studies are therefore needed that utilise a broad range of measures that include parent and/or teacher ratings of attention to understand further if IIC improve attention.

Zaldumbide-Alcocer et al. (2024) found improvements in a range of EFs, including inhibitory control, metacognitive control, planning and cognitive flexibility. However, significant gains from pre- to post-assessment were only seen in metacognitive control EFs. Additionally, effect sizes were not reported, so we cannot draw conclusions on the magnitude of changes. As there were no post-intervention follow-ups, it is difficult to draw conclusions regarding the long-term impact. Additionally, adaptive functioning was not measured, making it hard to draw

conclusions regarding the generalisability of the intervention to real life challenges. Other research on EF rehabilitation highlights limited effectiveness in a paediatric brain injury population (Brandt et al., 2021); however, a small-scale intervention highlighted the potential effectiveness in children with dyscalculia (Alipanah et al., 2022). Further studies are therefore required that consider the ecological validity of the intervention and assessment tools used to measure EF to further understand if IIC improve EF in children with epilepsy.

Given the limitations of the visuospatial study conducted by Saard et al. (2019), it cannot be concluded that IICs improve visuospatial domains. There is limited evidence to compare to, as many studies have looked at visuospatial domains as part of wider rehabilitation processes (Karch et al., 2013). Tallarita et al. (2019) found that adults with drug resistant temporal lobe epilepsy have intact non-memory visuospatial functions; however, their visuospatial span and long-term memory were significantly lower than healthy controls. This suggests that there may be a complex relationship between visuospatial functioning and memory in epilepsy, which should be explored in future studies.

Implications

Due to the inconsistency of the intervention approaches and measurements of cognition used across studies, there is a need for further research exploring cognitive rehabilitation in children with epilepsy, particularly more RCTs including varied epilepsy samples using an appropriate range of validated outcome measures, including adaptive functioning measures to capture any real-life, generalisable impacts of the interventions. Additionally, studies need to consider the long-term impact of

cognitive rehabilitation to ascertain whether results are durable, clinically meaningful, and therefore worth investing in through public funding. Considering the Limond et al. (2014) model, it may be that as other areas of cognition develop, techniques become inadequate and need to be updated. Therefore, it would be useful to understand if and when the impact of cognitive rehabilitation reduces back to baseline so that top up sessions could be provided as other cognitive domains improve. Finally, it would be useful to understand the mechanisms behind the changes seen during cognitive rehabilitation. Measuring engagement and confounding factors such as socioeconomic status may be useful to further understand factors that contribute to improvements in cognition in this population and would require far higher statistical power via larger samples, which was lacking in the included studies.

The findings of this review show limited and inconsistent results regarding WM, attention, EF and short-term memory rehabilitation in children with epilepsy. Therefore, no particular approach to cognitive rehabilitation could be recommended for clinical use at this time. This conclusion is drawn from a very small body of research, with only six studies being found even after thorough searching. However, these results match those from other cognitive rehabilitation research, including that of adults (Farina et al., 2015). Even high quality RCTs such as Kerr & Blackwell (2015) have mixed results and limited transfer effects from interventions. It is important, therefore, that future research considers the usefulness of additional research into cognitive rehabilitation in children with epilepsy. It may be important to focus on areas of psychosocial rehabilitation, which show more promising results (Mercier & Dorris, 2024). Nevertheless, Khaleghi et al. (2024) highlight that different modalities of

interventions should be considered in future research, as they found that paper and computer-based interventions were both effective in improving attention. This is important to consider in the settings where children have limited access to technology, such as rural areas. Additionally, Zaldumbide-Alcocer et al. (2024) highlight the importance of making interventions engaging, such as using Lego, which is key when considering interventions compete with other tasks such as homework and play. Considerations must also be given to the intensity of the intervention: for example, Kerr & Blackwell's (2015) intervention asks children to perform training five times a week, which may not be feasible for many families.

Limitations

There are a number of limitations of the present review. The exclusion criteria could be viewed as being overly narrow, as mixed adult and child samples were not included. The included results are also likely to be influenced by publication bias, whereby studies with significant findings are more likely to be published than those with non-significant findings. All studies included some significant results, despite some having major methodological limitations, highlighting this potential bias. This is often combated by completing grey literature searches; however, due to the limited time period to complete this review, extra searches were not conducted at this time. Studies also have a high risk of bias due to the small sample sizes with lack of power calculations, multiple outcome domains with mixed findings, no specification of primary outcomes, and lack of clearly defined baseline covariates. Future studies could consider relaxing the eligibility criteria to include the use of single-arm studies with no control group; however, this limits the conclusions that may be drawn as the

apparent impact of the intervention may be due to nonspecific aspects of the intervention, or indeed factors beyond the intervention.

The heterogeneity of the included studies is also a limitation, as variations in populations, interventions, and outcome measures reduce the ability to synthesize the results into a clear and cohesive understanding of the research landscape. This restricted the ability to conduct a meta-analysis as part of this review. Additionally, two of the studies (Saard 2017 & 2019) included the same intervention group participants. This limited the independence of the data, and consequently may inflate the evidence of the intervention effects. However, as these studies were both rated as poor, their findings were interpreted with caution and weighted accordingly. Only two studies were rated as high quality, which highlights the methodological weaknesses in this area of research. Although a formal GRADE assessment was not conducted due to the narrative nature of this review, the overall certainty of the evidence is likely low. Further studies should be conducted, drawing on the updated framework for developing and evaluating complex interventions, and adhering to best practice in contemporary clinical trial methodology (see Skivington et al. 2021), using standardised neuropsychological tests alongside validated measures of functional outcomes, and including a range of children with different types of epilepsy.

Conclusions

Due to the lack of high-quality studies, there is no evidence to support the efficacy and utility of cognitive rehabilitation for children with epilepsy who experience cognitive difficulties. Research should continue to strive to improve the quantity and quality of this research to try and improve functional and academic outcomes for these already

disadvantaged children. There should be a focus in future research on increasing sample sizes, utilising RCT methodologies, and using standardised cognitive assessments to measure outcomes of cognitive rehabilitation interventions.

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References

- Alipanah, M., Pourmohamadreza-Tajrishi, M., Nejati, V., & Vahedi, M. (2022). The Effectiveness of Cognitive Rehabilitative Program on Executive Functions in Children with Dyscalculia. *Archives of Rehabilitation*, 23(3), 352-371.
- Bharadwaj, S. V., Yeatts, P., & Headley, J. (2022). Efficacy of Cogmed Working Memory Training Program in Improving Working Memory in School-Age Children With and Without Neurological Insults or Disorders: A Meta-Analysis. *Applied Neuropsychology: Child*, 11(4), 891-903.
- Bayley, M. T., Janzen, S., Harnett, A., Teasell, R., Patsakos, E., Marshall, S., ... & McIntyre, A. (2023). INCOG 2.0 Guidelines for Cognitive Rehabilitation Following Traumatic Brain Injury: Methods, Overview, and Principles. *The Journal of Head Trauma Rehabilitation*, 38(1), 7-23.
- Ben-Yishay, Y., & Diller, L. (2011). *Handbook of Holistic Neuropsychological Rehabilitation: Outpatient Rehabilitation of Traumatic Brain Injury*. Oxford University Press.
- Besag, F. M., & Vasey, M. J. (2021). Neurocognitive Effects of Antiseizure Medications in Children and Adolescents with Epilepsy. *Pediatric Drugs*, 23(3), 253-286.
- Brandt, A. E., Finnanger, T. G., Hypher, R. E., Rø, T. B., Skovlund, E., Andersson, S., ... & Stubberud, J. (2021). Rehabilitation of Executive Function in Chronic Paediatric Brain Injury: A Randomized Controlled Trial. *BMC medicine*, 19, 1-15.
- Cherry, M. G., Boland, A., & Dickson, R. (2023). *Doing a Systematic Review: A Student's Guide* (3rd ed.). SAGE Publications, Inc.
- Cheng, D., Yan, X., Gao, Z., Xu, K., Zhou, X., & Chen, Q. (2017). Common and Distinctive Patterns of Cognitive Dysfunction in Children with Benign Epilepsy Syndromes. *Pediatric neurology*, 72, 36-41.

- Corrigan, F. M., Broome, H., & Dorris, L. (2016). A Systematic Review of Psychosocial Interventions for Children and Young People with Epilepsy. *Epilepsy & Behavior*, 56, 99-112.
- Cubillo, A., Hermes, H., Berger, E., Winkel, K., Schunk, D., Fehr, E., & Hare, T. A. (2023). Intra-Individual Variability in Task Performance After Cognitive Training is Associated with Long-Term Outcomes in Children. *Developmental Science*, 26(1), e13252.
- Dagar, A., & Falcone, T. (2020). Psychiatric Comorbidities in Pediatric Epilepsy. *Current Psychiatry Reports*, 22, 1-10.
- Davidson, M., Dorris, L., O'Regan, M., & Zuberi, S. M. (2007). Memory Consolidation and Accelerated Forgetting in Children with Idiopathic Generalized Epilepsy. *Epilepsy & Behavior*, 11(3), 394-400.
- Espinosa-Garamendi, E., Labra-Ruiz, N. A., Naranjo, L., Chávez-Mejía, C. A., Valenzuela-Alarcón, E., & Mendoza-Torreblanca, J. G. (2022). Habilitation of Executive Functions in Pediatric Congenital Heart Disease Patients through LEGO®-Based Therapy: A Quasi-Experimental Study. *Healthcare*, 10(12), 2348.
- Farina, E., Raglio, A., & Giovagnoli, A. R. (2015). Cognitive Rehabilitation in Epilepsy: An Evidence-Based review. *Epilepsy Research*, 109, 210-218.
- Gascoigne, M. B., Smith, M. L., Barton, B., Webster, R., Gill, D., & Lah, S. (2017). Attention Deficits in Children with Epilepsy: Preliminary Findings. *Epilepsy & Behavior*, 67, 7-12.
- Glaser, N. J., Schmidt, M., Wade, S. L., Smith, A., Turnier, L., & Modi, A. C. (2017). The Formative Design of Epilepsy Journey: A Web-Based Executive Functioning Intervention for Adolescents with Epilepsy. *Journal of Formative Design in Learning*, 1, 126-135.
- Ho, J., Epps, A., Parry, L., Poole, M., & Lah, S. (2011). Rehabilitation of Everyday Memory Deficits in Paediatric Brain Injury: Self-Instruction and Diary Training. *Neuropsychological Rehabilitation*, 21(2), 183-207.

- Ibekwe, R. C., Ojinnaka, N. C., & Iloeje, S. O. (2007). Factors Influencing the Academic Performance of School Children with Epilepsy. *Journal of Tropical Pediatrics*, 53(5), 338-343.
- Joplin, S., Webster, R., Gill, D., Barton, B., Lawson, J. A., Mandalis, A., ... & Lah, S. (2020). Accelerated Long-Term Forgetting in Children with Genetic Generalized Epilepsy: The Temporal Trajectory and Contribution of Executive Skills. *Epilepsy & Behavior*, 113, 107471.
- Karch, D., Albers, L., Renner, G., Lichtenauer, N., & von Kries, R. (2013). The Efficacy of Cognitive Training Programs in Children and Adolescents: A Meta-Analysis. *Deutsches Ärzteblatt International*, 110(39), 643-652.
- Kerr, E. N., & Blackwell, M. C. (2015). Near-Transfer Effects Following Working Memory Intervention (Cogmed) in Children with Symptomatic Epilepsy: An Open Randomized Clinical Trial. *Epilepsia*, 56(11), 1784-1792.
- Khaleghi, A., Naderi, F., Joharifard, R., & Javadzadeh, M. (2024). Comparing the Effectiveness of Computer-Based and Task-Oriented Cognitive Rehabilitation Programs on Epileptic Children's Attention in Tehran. *Journal of Comprehensive Pediatrics*, 15(1), e137309.
- Klingberg, T., Fernell, E., Olesen, P. J., Johnson, M., Gustafsson, P., Dahlström, K., ... & Westerberg, H. (2005). Computerized Training of Working Memory in Children with ADHD – A Randomized, Controlled Trial. *Journal of the American Academy of Child & Adolescent Psychiatry*, 44(2), 177-186.
- Kmet, L., Lee, R., & Cook, L. (2004). Standard Quality Assessment Criteria For Evaluating Primary Research Papers from a Variety of Fields.
- Langenbahn, D. M., Ashman, T., Cantor, J., & Trott, C. (2013). An Evidence-Based Review of Cognitive Rehabilitation in Medical Conditions Affecting Cognitive Function. *Archives of Physical Medicine and Rehabilitation*, 94(2), 271-286.

- Lee, L., Packer, T. L., Tang, S. H., & Girdler, S. (2008). Self-Management Education Programs for Age-Related Macular Degeneration: A Systematic Review. *Australasian Journal on Ageing*, 27(4), 170-176.
- Limond, J., Adlam, A. R., & Cormack, M. (2014). A Model for Pediatric Neurocognitive Interventions: Considering the Role of Development and Maturation in Rehabilitation Planning. *The Clinical Neuropsychologist*, 28(2), 181-198.
- Lin, J. J., Dabbs, K., Riley, J. D., Jones, J. E., Jackson, D. C., Hsu, D. A., ... & Hermann, B. P. (2014). Neurodevelopment in New-Onset Juvenile Myoclonic Epilepsy over the First 2 Years. *Annals of Neurology*, 76(5), 660-668.
- Marguet, S. L., Le-Schulte, V. T. Q., Merseburg, A., Neu, A., Eichler, R., Jakovcevski, I., ... & Isbrandt, D. (2015). Treatment During a Vulnerable Developmental Period Rescues a Genetic Epilepsy. *Nature Medicine*, 21(12), 1436-1444.
- Melby-Lervåg, M., & Hulme, C. (2013). Is Working Memory Training Effective? A Meta-Analytic Review. *Developmental Psychology*, 49(2), 270.
- Mercier, A., & Dorris, L. (2024). A Systematic Review of Psychosocial Interventions for Children and Young People with Epilepsy. *European Journal of Paediatric Neurology*, 49, 35-44.
- Modi, A. C., Mara, C. A., Schmidt, M., Smith, A. W., Turnier, L., & Wade, S. L. (2021). Pilot Executive Functioning Intervention in Epilepsy: Behavioral and Quality of Life Outcomes. *Journal of Pediatric Psychology*, 46(4), 363-374.
- Moorhouse, F. J., Cornell, S., Gerstl, L., Tacke, M., Roser, T., Heinen, F., ... & Borggraefe, I. (2020). Cognitive Performance and Behavior Across Idiopathic/Genetic Epilepsies in Children and Adolescents. *Scientific Reports*, 10(1), 21543.
- Mula, M., & Sander, J. W. (2016). Psychosocial Aspects of Epilepsy: A Wider Approach. *BJPsych Open*, 2(4), 270-274.

- Ng, A. C. H., Chahine, M., Scantlebury, M. H., & Appendino, J. P. (2024). Channelopathies in Epilepsy: An Overview of Clinical Presentations, Pathogenic Mechanisms, and Therapeutic Insights. *Journal of Neurology*, 1-32.
- Radford, K., Lah, S., Thayer, Z., & Miller, L. A. (2011). Effective Group-Based Memory Training for Patients with Epilepsy. *Epilepsy & Behavior*, 22(2), 272-278.
- Ratcliffe, C., Wandschneider, B., Baxendale, S., Thompson, P., Koepp, M. J., & Caciagli, L. (2020). Cognitive Function in Genetic Generalized Epilepsies: Insights from Neuropsychology and Neuroimaging. *Frontiers in Neurology*, 11, 144.
- Robbins, T. W., & Sahakian, B. J. (1983). *Computer Methods of Assessment of Cognitive Function*. In I. Hindmarch & H. Brice (Eds.), *Psychopharmacology and Reaction Time* (pp. 239–250). John Wiley & Sons.
- Reilly, C., Atkinson, P., Das, K. B., Chin, R. F., Aylett, S. E., Burch, V., ... & Neville, B. G. (2015). Factors Associated with Quality of Life in Active Childhood Epilepsy: A Population-Based Study. *European Journal of Paediatric Neurology*, 19(3), 308-313.
- Saard, M., Bachmann, M., Sepp, K., Pertens, L., Kornet, K., Reinart, L., ... & Kolk, A. (2019). Positive Outcome of Visuospatial Deficit Rehabilitation in Children with Epilepsy Using Computer-Based FORAMENRehab Program. *Epilepsy & Behavior*, 100, 106521.
- Saard, M., Kaldoja, M. L., Bachmann, M., Pertens, L., & Kolk, A. (2017). Neurorehabilitation with FORAMENRehab for Attention Impairment in Children with Epilepsy. *Epilepsy & Behavior*, 67, 111-121.
- Sarajuuri, J. M., & Koskinen, S. K. (2006). Holistic Neuropsychological Rehabilitation in Finland: The INSURE Program — A Transcultural Outgrowth of Perspectives from Israel to Europe via the USA. *International Journal of Psychology*, 41(5), 362-370.

- Schaffer, Y., Ben Zeev, B., Cohen, R., Shufer, A., & Geva, R. (2017). Memory, Executive Skills, and Psychosocial Phenotype in Children with Pharmacoresponsive Epilepsy: Reactivity to Intervention. *Frontiers in Neurology*, 8, 86.
- Schaffer, Y., & Geva, R. (2016). Short and Long Term Memory in Pediatric Idiopathic Epilepsy: Functions and Effect of Intervention. In E. A. Thayer (Ed.), *Spatial, Long-and Short-Term Memory: Functions, Differences and Effects of Injury* (pp. 75-92). Nova Science Publishers, Inc.
- Scheffer, I. E., Berkovic, S., Capovilla, G., Connolly, M. B., French, J., Guilhoto, L., ... & Zuberi, S. M. (2017). ILAE Classification of the Epilepsies: Position Paper of the ILAE Commission for Classification and Terminology. *Epilepsia*, 58(4), 512-521.
- Scott, H., Harvey, D. J., Li, Y., McLennan, Y. A., Johnston, C. K., Shickman, R., ... & Hessler, D. (2020). Cognitive Training Deep Dive: The Impact of Child, Training Behavior and Environmental Factors Within a Controlled Trial of Cogmed for Fragile X Syndrome. *Brain Sciences*, 10(10), 671-685.
- Skivington, K., Matthews, L., Simpson, S. A., Craig, P., Baird, J., Blazeby, J. M., ... & Moore, L. (2021). A new Framework for Developing and Evaluating Complex Interventions: Update of Medical Research Council Guidance. *BMJ*, 374.
- Symonds, J. D., Elliott, K. S., Shetty, J., Armstrong, M., Brunklaus, A., Cutcutache, I., ... & Zuberi, S. M. (2021). Early Childhood Epilepsies: Epidemiology, Classification, Aetiology, and Socio-Economic Determinants. *Brain*, 144(9), 2879-2891.
- Tallarita, G. M., Parente, A., & Giovagnoli, A. R. (2019). The Visuospatial Pattern of Temporal Lobe Epilepsy. *Epilepsy & Behavior*, 101, 106582.
- Warsi, N. M., Wong, S. M., Gorodetsky, C., Suresh, H., Arski, O. N., Ebdon, M., ... & Ibrahim, G. M. (2023). Which is More Deleterious to Cognitive Performance? Interictal Epileptiform Discharges vs Anti-Seizure Medication. *Epilepsia*, 64(5), e75-e81.

- Wilson, B. (1989). Models of Cognitive Rehabilitation. In R. L. Wood & P. Eames (Eds.), *Models of Brain Injury Rehabilitation* (pp. 117–141). Johns Hopkins University Press.
- Wirrell, E., Wong-Kissel, L., Mandrekar, J., & Nickels, K. (2012). Predictors and Course of Medically Intractable Epilepsy in Young Children Presenting Before 36 Months of Age: A Retrospective, Population-Based Study. *Epilepsia*, 53(9), 1563-1569.
- Zaldumbide-Alcocer, F. L., Labra-Ruiz, N. A., Carbó-Godinez, A. A., Ruíz-García, M., Mendoza-Torreblanca, J. G., Naranjo-Albarrán, L., ... & Espinosa-Garamendi, E. (2024). Neurohabilitation of Cognitive Functions in Pediatric Epilepsy Patients Through LEGO®-Based Therapy. *Brain Sciences*, 14(7), 702-722.

Chapter 2

The accessibility of an adapted version of the Zoo Map subtest of the Behavioural Assessment of the Dysexecutive Syndrome for Children (BADS-C) in a paediatric epilepsy sample

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Plain Language Summary

Background

Executive functioning (EF) can be defined as the evolutionary advantage of minimising automatic responses and instead engaging with behaviours that will help us to reach a specific goal, e.g. planning complex work-related tasks to maintain employment (Suchy, 2009). In young people with epilepsy, EF can be impaired, leading to difficulties at home and school, such as impulsive behaviour and poor grades (Culhane-Shelburn et al., 2002). EF can be measured in several different ways, including parent and teacher ratings, naturalistic tasks such as cooking, and behavioural measures completed in one-to-one settings. Behavioural measures are important as they reduce subjectivity of people who know the child and are less impacted by culture. However, many of the behavioural measures have been derived from adult tests, and may not consider other areas of development such as language, making them inaccessible to children (Lee et al., 2013).

Aims and Questions

The aim of this study is to validate a low-language version of the Zoo Map from the Behavioural Assessment of Dysexecutive Syndrome for Children (Emslie et al., 2003). This is a task where children have to plan a route around a zoo to visit different animals.

The primary aim was to explore how accessible the adapted Zoo Map is. There were several secondary questions, including if the test correlates with a parent measure of EF.

Methods

- Participants: 24 children with Genetic Generalised Epilepsy aged 9-15.
- Recruitment: Children were recruited from children's hospitals in Glasgow and Edinburgh. They were asked to take part by a member of their epilepsy care team.
- Design of study: An experimental design in which children either completed the original or adapted Zoo Map.
- Data collection: Data was collected on language skills, intelligence, parent rated EF and epilepsy, as well as either the original or adapted Zoo Map.

Main Findings and Conclusions

The adapted Zoo Map is feasible and more accessible than the original, as it took less time to administer, less children discontinued the adapted task compared to the original, and the examiner did not have to provide more prompts. Using this test could increase accessibility of neuropsychological services, particularly for young people with language difficulties, but further studies with a bigger sample would be needed to understand this further. Scores on the adapted Zoo Map were not significantly different from the original version, suggesting that they both measure planning. However, the adapted Zoo Map scores did not correlate with parent-rated EF. Therefore, further research is needed to improve the accessibility of EF testing in children.

Abstract

Objective

A feasibility study exploring the accessibility of an adapted, primarily pictorial, version of the Zoo Map subtest from the Behavioural Assessment of the Dysexecutive Syndrome for Children (Emslie et al., 2003), which is a pen-and-paper measure of planning that requires the child to plan a route around a zoo, considering several rules and specifications. The primary research question was whether the adapted version of the Zoo Map was more accessible than the original, with additional supplementary questions exploring convergent validity; relation to verbal comprehension; and ecological validity.

Method

A between-subjects experimental design was used. Participants were 24 children aged 9-15 years with a diagnosis of Genetic Generalised Epilepsy and an IQ ≥ 70 . Participants completed several neuropsychological assessments, including either the original or adapted Zoo Map test. A number of feasibility outcome measures were taken, including length of time to deliver the test instructions, number of scaffolds provided by the examiner, and number of discontinued assessments, in addition to measures of performance.

Results

In line with our hypotheses, the adapted version of the Zoo Map took less time to administer ($M = 54.6$ seconds, $SD = 12.7$) compared to the original version ($M = 132$

seconds, $SD = 30.4$; Cohen's $d = 3.2$). A quarter of children discontinued the original task, whereas none discontinued the adapted version. There were no differences in the number of prompts provided or discontinuation rates. Planned secondary analyses, which were underpowered due to the small sample, indicated scores on the Zoo Map across the two groups were similar, indicating potential construct validity; however, scores on the adapted Zoo Map did not correlate with parent-reported executive functioning, so evidence of ecological validity is lacking. Additionally, correlations between the original vs adapted Zoo Map and verbal comprehension were similar.

Conclusion

These promising initial findings suggest that adapting standardised measures by reducing language load can shorten administration time. The adapted Zoo Map could be incorporated into wider assessment batteries for a range of children, including those with language impairment or language diversity, following studies with larger, more diverse samples. Use of the adapted measure could hence facilitate the identification of executive function problems in children with epilepsy, an important clinical objective.

Introduction

Executive Functioning and its Development

Executive function (EF) is defined as the evolutionary advantage of minimising automatic responses to engage in goal directed behaviour (Suchy, 2009). In a review article, Friedman and Robbins (2022) argue that there are three variables that compose EF: inhibition (stopping an automatic response); working memory (WM; holding information in mind and manipulating it); and shifting (moving between two separate tasks). EF is important to consider in children, as it is linked to future academic success (Ahmed et al., 2018), mental health outcomes (Yang et al., 2022), and fundamental decision making and self-awareness. The development of EF is non-linear, with foundational abilities such as sustained attention and habituation emerging in the first year of life. Theory of mind, simple planning and switching emerging between the ages of two and five (Anderson, 2002). Inhibition matures in middle childhood (six to eight), with shifting and WM maturing into adolescence (Best & Miller, 2010). EFs such as WM and problem solving continue to develop into late adolescence (Blakemore & Choudhury, 2006). In particular, cognitive empathy, which is one's ability to recognise and draw conclusions about the thoughts and feelings of others, reaches functional maturity at around age 25 (Dorris et al., 2022). These studies highlight the emerging, qualitatively different nature of EF in childhood compared to adulthood.

In keeping with the age-differentiation hypothesis (Tucker-Drob, 2009), EF variables become less inter-related as children age and their brains develop. Hughes et al. (2009) found that tasks involving planning, inhibition and WM mapped statistically

onto a single, latent construct in children ages 4 and 6. A similar study by Lee et al. (2013), found that EF skills of children aged 6 to 15 map onto a two-factor model, with WM becoming a distinct factor and inhibition and flexibility staying as one factor. At 15, a three-factor model including the skills indicated by Friedman and Robbins (2022) appears to best explain EF. These studies indicate that EF increases in complexity with age, which coincides with neuronal migration from proximal brain areas to more distal ones (Koziol & Lutz, 2013).

Neuroimaging studies point towards qualitative differences in adult and child EF. In a fMRI study, Engelhardt et al. (2019) tested 117 twins/triplets, aged 7-13, on switching, inhibition and updating tasks, and found that regions within the frontoparietal and cingulo-opercular networks were activated throughout EF tasks, which is similar to adult activation. However, activated brain regions in children were more proximal to the mid brain compared to adults; for example, activation in the inferior parietal lobe was, on average, 19mm distal from adult activation. Furthermore, additional brain areas are often activated when children complete EF tasks compared to adults, such as the frontal eye field. This may suggest that, during aging, networks have qualitative changes that reflect underlying neural specialisation. Fair et al. (2007) found that frontal networks involved in EF tasks in children are more interconnected, particularly the anterior and dorsolateral prefrontal cortex, whereas in adults these areas form part of two separate brain networks involved in EF. However, evidence is not conclusive, with a review by Goddings et al. (2021) summarising that some studies find a link between inhibitory control and fractional anisotropy in frontal white matter regions in children, but other studies do not. They

concluded that more studies are needed to further understand the link between brain development and EF.

EF must also be considered alongside the development of other areas of cognition in children. For example, a literature review by Shokrkon & Nicoladis (2022) highlights the relationship between language and EF development, and that both may impact the development of the other. However, they indicate that the high language load of EF tests may confound understanding of the relationship between EF and language development. Additionally, an experimental study exploring the relationship between EF and memory in children with epilepsy found that WM performance predicted 9-19% of variance in memory performance (Sepeta et al., 2017). This highlights the importance of considering EF alongside the development of other areas of cognition in children.

Assessing Executive Functioning

How we understand EF and its development is dependent on how it is assessed. Researchers have argued that the use of ‘watered-down’ adult tests of EF with children may not be useful, as the concepts they measure may not yet have developed (Lee et al, 2013). Therefore, tests used in paediatric populations may lack validity – they may not measure what they set out to measure, (Koziol & Lutz, 2013). In particular, it is important to consider the ecological validity of tests of EF in children, both in terms of the extent to which they mimic real life environments and tasks (i.e. their verisimilitude), and, more importantly, their ability to predict EF performance in ‘real life’ (i.e. their veridicality), as the two do not necessarily go hand-in-hand (Suchy et al. 2024).

Assessing EF allows for: monitoring cognitive change associated with medical treatment (Operto et al., 2020), estimating the impact of head injury or other neurological condition (Nadebaum et al., 2007), and tailoring care plans to best accommodate deficits (Otero et al., 2014). There is no single agreed upon assessment approach to measure EF. Often, tests have developed from experimental paradigms, conducted in controlled clinical environments in a highly structured manner that may reduce their ability to pick up everyday EF challenges (Burgess et al., 2006). Several single tests have been developed, as well as batteries of assessments that aim to cover several EFs. However, as mentioned, EF is not fully developed until adulthood. Therefore, using tests with children that are based on adult theories may lack construct validity, and may not sufficiently account for their more limited development of other cognitive functions such as language and memory. This is crucial to consider, as many EF tests have substantial spoken or written language requirements. This is a particular problem for individuals with language disorders and/or diversity, who may be excluded from such assessments, or whose performance may erroneously be interpreted as indicative of EF impairment rather than of language ability (Stålhammar et al., 2022).

There are several ways to measure EF: traditional pen-and-paper cognitive tests, more naturalistic tasks, and informant-based questionnaires. Traditional tests of EF typically involve individual or a battery of tasks that assess some components of EF, such as the Stroop, Trail Making Test and Verbal Fluency subtests of the Delis-Kaplan Executive Function System (Delis et al., 2001), developed over many years and with extensive norms. Naturalistic measures require children to perform tasks they might encounter during their day-to-day lives, such as cooking (Rocke et al., 2008), which

often draw upon a wide range of EFs such as initiation, organisation and planning. The current research on these tasks is relatively limited, often using small sample sizes with a single condition, e.g. brain injury, making it hard to generalise the findings or consider norms (Robertson & Schmitter-Edgecombe, 2017). Additionally, these tasks may be culturally bound, and children's previous exposure to them may vary, meaning that performance can be more difficult to interpret, and applicability across cultural groups may be limited. A widely used informant-based measure is the Behavior Rating Inventory of Executive Function (BRIEF; Gioia et al., 2015). It gives insight into tasks at home or in the classroom that map onto EF; however, teachers and parents may over or under-estimate a child's ability. Therefore, standardised behavioural EF measures remain an important, objective addition to informant-based subjective measures. Behavioural measures, however, must be considered for their veridicality and verisimilitude. Often, measures are compared to the BRIEF, and may not correlate highly (Wallisch et al., 2018). This may in part be due to behavioural measures being highly structured, unlike many natural environments, so tests lack verisimilitude. The Behavioural Assessment of the Dysexecutive Syndrome for Children (BADSC; Emslie et al., 2003) was adapted from an adult battery and designed with ecological validity in mind. There is some evidence of its predictive validity in children, as BADSC scores were found to significantly correlate with ratings of hyperactivity and peer relationships in a heterogeneous clinical sample (Fish & Wilson, 2021). However, these were weak correlations, indicating that the predictive power of BADSC scores may be limited. A study by Romundstad et al. (2023) looking more specifically at children with acquired brain injuries, however, found that the Zoo Map and Key Search Test in the

BADS-C had predictive and concurrent validity, as well as veridicality. Therefore, these tests are worthy of further research.

Executive Functioning in Children with Epilepsy

Neuropsychological assessment can be key when considering the care plan for young people with neurological conditions, including epilepsy. In a prospective, multicentre, population-based study using neuroimaging and genetic testing, Symonds et al. (2021) found the incidence of epilepsy was approximately 1 in every 418 children in Scotland (Symonds et al, 2021). Earlier retrospective studies have found smaller incidence rates, with 44.5 in every 100,000 children being diagnosed in America (Wirrell et al., 2011). Nonetheless, epilepsy is a common childhood condition. Epilepsy can have a wide-ranging impact on cognition, such as memory, attention and overall intelligence (Elger et al., 2004). There are several aetiologies that underlie epilepsy, including conditions such as encephalitis and cerebral palsy, or they can be idiopathic. Different aetiologies lead to different epileptic, cognitive and behavioural outcomes. An epilepsy syndrome that impacts a quarter of all children with epilepsy is Genetic Generalised Epilepsy (GGE), which encompasses Childhood Absence Epilepsy and Juvenile Myoclonic Epilepsy (Mullen & Berkovic, 2018). In a review of 49 studies with at least 1,400 overall participants investigating the impact of GGE on cognition, Ratcliffe et al. (2020) highlighted several areas of cognition that have been found to be impacted, including attention, processing speed and EF. However, the studies included in this review used a wide range of neuropsychological assessments, making it hard to conclude that differences in results are due to difference in cognition rather than how the children were assessed.

Considering EF specifically, there is disagreement regarding whether individuals with GGE show deficits. Abarategui et al. (2018) performed a large neuropsychological battery exploring attention, EF, memory and visuospatial skills with 61 adults with GGE and compared them to controls. While individuals with GGE performed worse on some EF tests (e.g. Stroop), they did not differ significantly on others (e.g. Tower of London). This inconsistency may reflect limitations in the battery of tests used, as they vary in sensitivity and specificity to EF. Additionally, without correction for multiple comparisons, some significant findings may be due to type I errors. It is therefore hard to draw firm conclusions about the extent of EF impairments in GGE. In another study, Chowdhury et al. (2014) found that adults with GGE performed significantly worse on attention and WM tests, but not the Trail Making Test Part B, which is inconsistent with Abarategui et al.'s (2018) findings. As the two studies used different tests and have different designs, this may confound the findings. In a study comparing 59 adolescents with GGE to controls, Gelžinienė et al. (2011) found that adolescents with GGE performed significantly worse on tasks of fluency, attention and WM, but not inhibition. Variability in findings are likely due to sample compositions, such as age, severity of epilepsy, medication and intellectual ability. Further studies with rigorous methodology are therefore needed to explore the impact of epilepsy on EF further. Additionally, considering how tests could add to already established measures of cognition, including IQ, is key when considering clinical utility.

In a study looking at children with temporal and frontal lobe epilepsy, Culhane-Shelburn et al. (2002) found that performance on EF tests was a predictor of adaptive

functioning. This is key when considering clinical utility, such as creating care plans for home and school, and may suggest that compensation of EF skills may lead to better adaption in these environments. However, as children with GGE were not included in this sample, future research is needed to understand if this correlation is found in all types of epilepsy. When considering treatment of GGE, anti-seizure medication is the recommended approach once a diagnosis has been obtained (NICE, 2022). A

longitudinal study by Rathouz et al. (2014) found that deficits in EF of children with GGE compared to 'typically developing' children were identifiable from first diagnosis and remained stable over time. This may suggest that deficits in EF are organic and are not linked to medication use. A study by Reuner et al. (2016) indeed found that EF deficits were seen prior to medication use, but also that children with new-onset epilepsy had fewer impairments than those who had been taking medication for longer.

As children with GGE are at increased risk of EF impairment and, given EF impairment can have lasting consequences for social and educational function alongside subsequent cognitive development, an ecologically valid tool for measuring EF would have clinical utility and allow for the accurate identification of EF difficulties, as well as enable improved management and rehabilitation of EF difficulties over the lifespan. Additionally, a tool that increases accessibility for all children, particularly those with language differences, would improve access to neuropsychological services and is another key consideration for EF research.

Aims of the Current Study

The current study aimed to address some of the conceptual and theoretical issues highlighted above by testing an adapted version of the Zoo Map subtest of the BADS-C that has reduced spoken and written language demands. This study aimed to test the feasibility of using this adapted measure, relative to its standard version, in clinical practice, and as such focused on aspects of administration and usability of the tool. Although this was a small-scale study that could in principle inform future larger trials, we did not set out to assess the feasibility of conducting a future definitive study comparing the original vs adapted Zoo Map test.

Primary research question: Is the adapted Zoo Map more accessible than the original version?

- Hypothesis 1.1: The adapted version will result in fewer participant discontinuations relative to the original.
- Hypothesis 1.2: The adapted version will require less time for the clinician to explain instructions relative to the original.
- Hypothesis 1.3: The clinician will need to provide less scaffolding during administration of the adapted version relative to the original.

There were also several secondary exploratory research questions. The first examined if scores differed between the adapted and original Zoo Map.

- Hypothesis 2: No significant differences will be found between the Zoo Map versions (effect sizes may be of relevance to the planning of further studies;

due to the focus of this study on feasibility we were not powered to detect differences smaller than Cohen's $d = .8$).

The second exploratory research question investigated whether the adapted Zoo Map had a weaker association with a measure of verbal comprehension abilities than the original.

- Hypothesis 3: The adapted Zoo Map will correlate less strongly with verbal comprehension compared to the original version.

Finally, the study assessed the ecological validity of the adapted Zoo Map.

- Hypothesis 4: Performance on the adapted Zoo Map will correlate with BRIEF-II scales.

Method

Design

This study used a between-subjects quantitative experimental design. This was selected to prevent practice effects and task familiarity influencing the results over repeated administrations. This was a feasibility study, with a focus on elements such as time taken to deliver the instructions and number of prompts provided to young people. Participants were pseudo-randomly assigned to either the original or adapted Zoo Map using a Latin Square. Group allocation was based on age, split by 2-year epochs, and verbal comprehension (below average <90; average 90-110; above average >110 as determined by British Picture Vocabulary Scale [BPVS] score) to

ensure, as far as possible, that the experimental groups were balanced on these variables. For the feasibility research questions, the independent variable was Zoo Map version (original vs. adapted), and the dependent variables were number of prompts and answers to questions given (to index 'scaffolding'); amount of time taken to deliver the instructions; and whether the task was discontinued. For the secondary questions, the independent variable was Zoo Map version, and the dependent variables were Zoo Map 1 age scaled score; verbal comprehension (as measured by the BPVS); and BRIEF scales. To obtain 80% power to detect large effects (Cohen's $d=.8$), where $p=0.05$, for hypotheses 1.2 and 1.3, a sample size of 42 (21 in each group) was required. Due to difficulties encountered during data collection (e.g. recruitment during a time of high clinical demand and alongside other studies), and despite adding an additional recruitment site, this sample size was not met, with 24 being recruited. This reduced sample size gave only 60% power to detect equivalent effects.

Ethics

This project was approved by NHS Greater Glasgow and Clyde (Appendix 6), NHS Lothian (Appendix 7) and North of Scotland Research Ethics Committee (24/NS/0037; Appendix 8). A substantial amendment was submitted and approved (Appendix 9) to access information from neuropsychological assessments participants may have completed previously.

Consent from children and parents to participant was obtained at the beginning of assessment sessions. If children were under the age of 12, their parents gave consent whilst the child assented to the process. If children were over the age of

12, they provided consent, and their parents assented to testing. If either the parent or child declined consent/assent, the testing session did not proceed.

Participants

Participants were recruited from paediatric neurology services at the Royal Hospital for Children in Glasgow and the Royal Hospital for Children and Young People in Edinburgh, over a 9-month period between September 2024 and June 2025. Potential participants were identified and asked to take part in the study by members of their epilepsy care team. All children met the following criteria: (i) between the ages of 8 years and 15 years 11 months at the time of the assessment; (ii) a confirmed diagnosis of GGE; (iii) understand enough English to complete the assessment without an interpreter (due to lack of resources to fund interpretation); and (iv) have an IQ of greater than 70 (as the BADS-C was not standardised for use with children with IQs below this).

Individual consultants reviewed case loads and were prompted by researcher during weekly meetings if they were able to attend.

Materials

Zoo Map Task: Original and Adapted Versions

The original Zoo Map subtest within the BADS-C (Emslie et al., 2003) is a test in two parts. In the first part (Zoo Map 1), the child is shown a map of a zoo and asked to plan a route so they can see certain animals, according to particular rules. The task requirements are explained verbally and with a written summary. Planning this route places high demands on EFs, particularly those associated with planning. In the second

part (Zoo Map 2), the executive demands are removed, as the optimal order is revealed.

The adapted version of the Zoo Map was developed from a pictorial adaptation of the adult version of the Zoo Map from the BADS (Wilson et al., 1996), developed by Dr Joanna Atkinson (personal communication, see Appendix 5). The language demands were reduced by replacing much of the written language within the instructions with visual images. Additionally, rather than the examiner reading the manualised instructions, gestures are used to communicate to the participant what is needed of them. Scoring of the adapted Zoo Map was consistent with the original, focusing on rule adherence and route efficiency. Two separate scores were generated – a score for Zoo Map 1 and a score for Zoo Map 2. For the current study, only the results of Zoo Map 1 were considered.

British Picture Vocabulary Scale (BPVS)

The BPVS (Dunn et al. 2009) is a receptive vocabulary assessment that involves the examiner saying a word and the child selecting a picture from a choice of four that most closely represents the word. Standardised scores were calculated and used.

Behavior Rating Inventory of Executive Function 2nd Edition – Parent Version (BRIEF)

The BRIEF-II – Parent version was developed by Gioia et al. (2015). It is an informant measure where parents rate the severity of different EF difficulties, including planning, shifting and emotional control. Several subscales and overall scores can be calculated to understand the severity of a child's specific and global EF difficulties. For the current study, the planning/organisation scale; cognitive regulation index (CRI); and

Global Executive Composite (GEC) are reported on. As the Zoo Map task is predominantly a planning task (Emslie et al., 2003; Fish & Wilson 2021), the planning/organisation scale was most appropriate for analysis. However, due to the complex nature of EF, particularly in children, it was important to also consider the wider EFs, captured using the CRI and GEC.

Intellectual Functioning

Intellectual functioning was estimated via the Vocabulary and Matrix Reasoning subtests of the WASI-II (Wechsler et al., 2011) using the FSIQ-2; or, if IQ score was available from a neuropsychological assessment completed within the last 12 months, these were obtained from clinical notes.

Procedure

Data were collected by a member of the research team who was trained to administer and score the measures. The tests were administered in the following order:

- BPVS
- If required, Matrix Reasoning from the WASI-II
- If required, Vocabulary from the WASI-II
- Original or adapted Zoo Map.

For the BPVS, WASI-II subtests and original Zoo Map, the standardised instructions were followed. However, flexibility was used in administration where appropriate: for example, encouraging pointing to picture on the BPVS for younger children; or the examiner reading the instructions on the Zoo Map card if the child was not a confident

reader. For the adapted Zoo Map, the examiner used as little language as possible apart from a few key phrases:

- Here is a zoo
- You have to draw a plan to visit these animals
- Follow these instructions

The young person was given time to go through the instructions as many times as necessary. The examiner also pointed to the corresponding items on the map, such as the camels and the shaded areas, as necessary, but language was kept to a minimum.

During testing, the examiner took measures of feasibility, including: (i) time taken to explain the instructions before starting the Zoo Map task, measured in seconds, as measured by smartphone app; (ii) number of prompts given by the examiner, using a tally chart on the experimental scoresheet; and (iii) if the task had to be discontinued.

Parents completed the BRIEF-II and a demographic questionnaire (Appendix 10) during the testing session. Following data collection, parents who had provided their email address received a lay summary outlining the results of the study.

Data Analysis

Data were analysed using SPSS v.29 (IBM Corp., 2022). For hypothesis 1.1, a Fisher's Exact test was used to compare number of participants who discontinued for each Zoo Map condition. Frequencies were also reported.

For hypothesis 1.2, a Shapiro-Wilk test was performed to determine the distribution of time taken to deliver the instructions based on Zoo Map condition. This showed that the distribution of time taken to deliver the instructions differed significantly from normality for the adapted Zoo Map ($W = .831$, $p = .022$). Therefore, a Mann Whitney U test was performed to evaluate whether the time taken to deliver the instructions differed by Zoo Map condition. Means and standard deviations were also reported.

For hypothesis 1.3, a Shapiro-Wilk test was performed to determine the distribution of number of scaffolds given based on Zoo Map condition. This showed that the original ($W = .735$, $p = .002$) Zoo Map differed significantly from normality. Therefore, a Mann Whitney U test was performed to evaluate whether the number of scaffolds given differed by Zoo Map condition. Means and standard deviations were also reported.

For hypothesis 2, a Shapiro-Wilk test was performed to determine the distribution of Zoo Map 1 age scaled scores based on Zoo Map condition. This showed that the distribution of age adjusted scale score for Zoo Map 1 was normal for both the original ($W = .936$, $p = .444$) and adapted Zoo Map ($W = .929$, $p = .370$). Therefore, a t-test was performed to evaluate whether Zoo Map 1 age scaled scores differed by Zoo Map condition. Means and standard deviations were also reported.

For hypothesis 3, two correlations were performed comparing each type of Zoo Map age scaled score with verbal comprehension. The results of these were then compared using a Fisher's r-to-Z test.

For hypothesis 4, correlations were performed to see if planning/organisation, CRI or GEC scores on the BRIEF were correlated with Zoo Map scores for the adapted version only.

Results

Demographics and Recruitment

Participants were recruited over a 9-month period in Glasgow and 1-month in Lothian.

In this time, 18 participants were recruited from Glasgow and 6 from Lothian.

Neurologists, epilepsy nurse specialists and neuropsychologists reviewed their caseload during weekly meetings to identify potential participants. The first author attended as many weekly meetings as possible to facilitate recruitment, but as this was not always possible, some potential participants may have been missed.

25 children were recruited through convenience sampling, with one excluded due to estimated IQ < 70. The remaining 24 were pseudorandomised to the original (n=12) or adapted (n=12) Zoo Map condition. All children completed the procedure, with none choosing to withdraw from the study.

Table 3 depicts the clinical and demographic characteristics of the group. No significant differences were found between the two Zoo Map groups on these key demographic characteristics; see Appendix 11.

Primary Feasibility Outcomes

A Fisher's exact test was used to determine if there was a significant difference in the frequency of discontinuation between Zoo Map conditions. Although three children in the original condition discontinued the Zoo Map, versus none in the adapted condition (see Table 4), and despite a large effect size, this difference was not statistically significant ($p = .217$, corrected OR = .109).

Table 4 - Demographic and Clinical Characteristics of Participants by Zoo Map Version

Characteristic	Original (n = 12)	Adapted (n = 12)
<i>Age</i>	$\bar{x}$ 12 years 5 months (SD 1.75)	$\bar{x}$ 13 years 1 month (SD 1.48)
<i>Gender</i>		
Male	n = 5 (42%)	n = 4 (33%)
Female	n = 7 (58%)	n = 8 (67%)
<i>IQ</i>	$\bar{x}$ 99.58 (SD 12.53)	$\bar{x}$ 99.42 (SD 14.52)
<i>Verbal Comprehension score (BPVS)</i>	$\bar{x}$ 94.58 (SD 15.58)	$\bar{x}$ 95.17 (SD 8.75)
<i>BRIEF-II GEC</i>	$\bar{x}$ 57.33 (SD 4.00)	$\bar{x}$ = 60.08 (SD 2.79)
<i>Length of Diagnosis</i>	$\bar{x}$ 1 year 9 months (SD 1.74)	$\bar{x}$ 2 years 6 months (SD 2.44)
<i>Frequency of Seizures</i>		
Daily	n = 4 (33%)	n = 2 (17%)
Weekly	n = 0 (0%)	n = 0 (0%)
Monthly	n = 2 (17%)	n = 1 (8%)

More than monthly n = 6 (50%)

n = 9 (75%)

Number of Anti-Epileptic

Medications

0 n = 2

n = 0

1 n = 8

n = 8

1+ n = 2

n = 4

$\bar{x}$ = mean, SD = standard deviation, IQ = intelligence quotient, BPVS = British Picture Vocabulary Scale, BRIEF-II = Behaviour Rating Inventory of Executive Function, Second Edition, GEC = General Executive Composite

Table 5 - Number of Children who Discontinued the Zoo Map based on Version

		Zoo Map Condition	
		Original	Adapted
Task discontinued	Yes	3	0
	No	9	12

A Mann Whitney U test was performed to evaluate whether the time taken to deliver the instructions differed by Zoo Map condition. The results indicated that there was a significant difference with a large effect size (time [seconds] in original condition

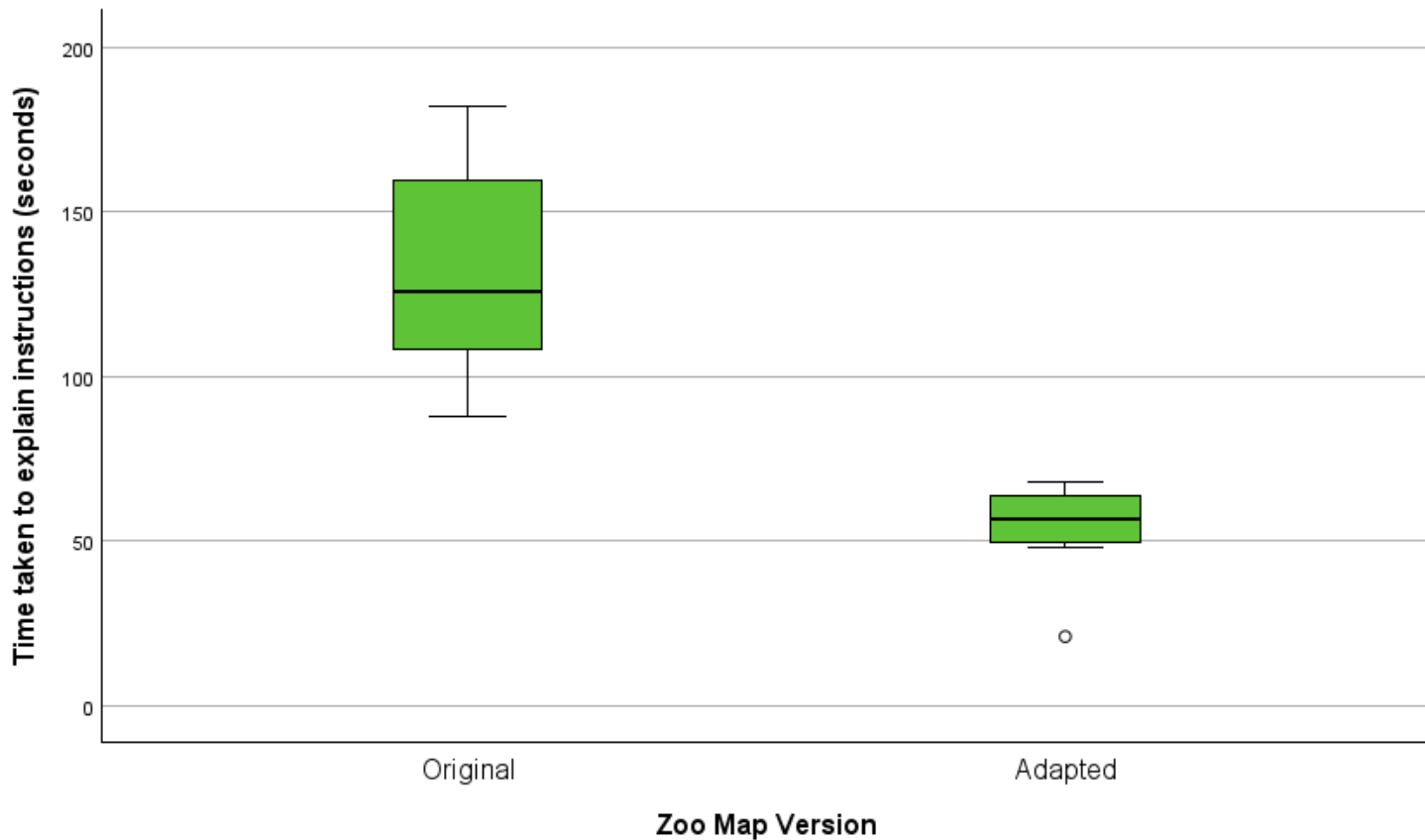


Figure 2

Boxplot depicting Time Taken to Explain Instructions based on Zoo Map Version

M = 132.00, SD = 30.36; time in adapted condition M = 54.58; SD = 12.67; U = .000, $p < .001$, Cohen's $d = 3.207$). Therefore, it takes less time to deliver the instructions for the adapted Zoo Map condition compared to the original version (see Figure 2).

A Mann Whitney U test was performed to evaluate whether the number of scaffolds given differed by Zoo Map condition. The results indicate that there was not a significant difference between number of scaffolds given based on Zoo Map condition (scaffolds in original condition M = 4.67, SD = 4.81; scaffolds in adapted condition M = 3.17, SD = 1.59; U = 68.5, $p = .834$, Cohen's $d = .083$).

Secondary Exploratory Analyses

A t-test was performed to evaluate whether age adjusted scaled score for Zoo Map 1 differed by Zoo Map condition. The results indicate that there was no significant

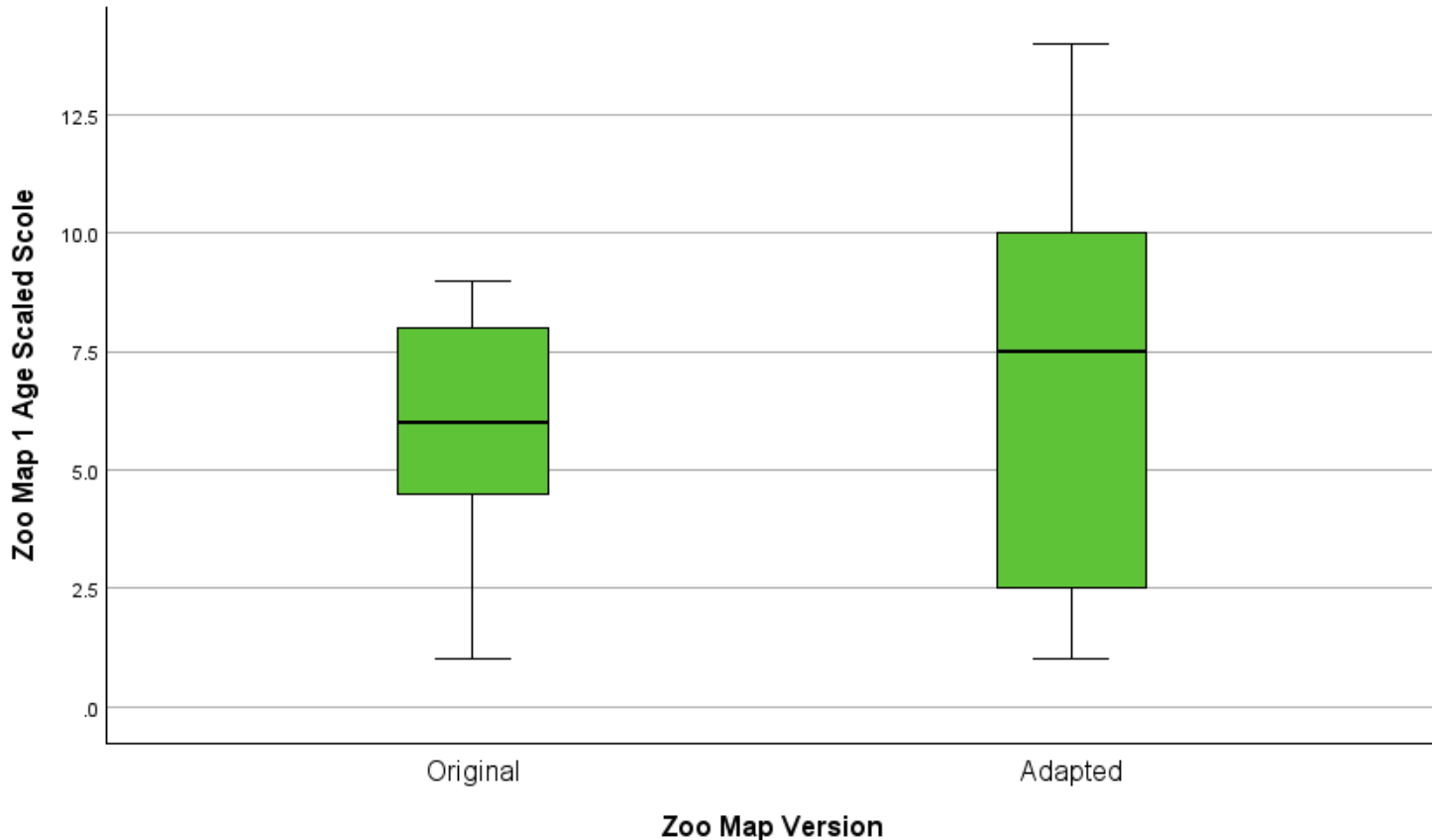


Figure 3

Boxplot depicting Zoo Map 1 Age Scaled Score based on Zoo Map Version

difference between the two conditions (original $M = 5.92$, $SD = 2.35$; adapted $M = 6.92$, $SD = 4.32$; $t(22) = -.705$, $p = .244$, Cohen's $d = .288$; see Figure 3). This small effect size may indicate that children in the adapted condition performed slightly better than the original condition. However, the study was not powered to detect small effects, and more data would be required before any firm conclusions are drawn.

Pearson's correlations were calculated for Zoo Map 1 age scaled score and BPVS score, based on Zoo Map condition, separately. The small correlation between original Zoo Map age adjusted scale and BPVS score was not statistically significant ($r =$

-.180, $n = 12$, $p = .576$), and neither was the medium correlation between the adapted Zoo Map and BVPS scores ($r = -.337$, $n = 12$, $p = .285$). A comparison of these correlations using Fisher's r -to- z transformation revealed no significant difference between the groups ($z = .36$, $p = .72$).

Pearson's correlations were performed to determine whether the adapted Zoo Map 1 age scaled score was associated with the BRIEF planning/organisation scale, CRI, and GEC. The adapted Zoo Map 1 scores did not correlate significantly with planning/organisation, with small to medium correlations identified ($r = -.327$, $n = 12$, $p = .300$); CRI ($r = -.310$, $n = 12$, $p = .328$); or GEC ($r = -.260$, $n = 12$, $p = .414$).

Discussion

The current study aimed to test an adapted, low-language, pictorial version of the Zoo Map subtest from the BADS-C (Emslie et al., 2003), which measures planning skills, in a group of children with GGE, where EF deficits are common (Gelžinienė et al., 2011). In children, the ability to plan effectively is associated with key developmental outcomes such as academic success (Best et al., 2011), so it is important to assess in clinical practice. We had three feasibility hypotheses, predicting that the adapted Zoo Map would result in fewer children discontinuing the task; it would take less time to administer the instructions; and the clinician would need to provide less scaffolding during administration compared to the original version. We also had several exploratory hypotheses: there would be no difference in scores between the original and adapted Zoo Map; that the adapted Zoo Map would be less associated with verbal

comprehension compared to the original version; and performance on the adapted Zoo Map would correlate with parent-rated BRIEF scores. Overall, this study signals the feasibility of this adaptation, with significantly reduced clinician administration time, and with a nonsignificant reduction in discontinuations. This highlights the potential use in clinical practice and also potential for further studies to explore its use with wider populations.

In terms of our feasibility hypotheses, we found that the adapted Zoo Map took significantly less time to administer compared to the original version. This suggests that the adapted Zoo Map has feasibility, as it reduced clinician administration time and reduced language complexity for young people receiving the test. Therefore, this adaption is not unfeasible to consider incorporating into clinical practice. In another feasibility study exploring 67 children's experience of neuropsychological testing (Jones et al., 2022), the mean appointment time was nearly six and a half hours, with 39% of children reported that they were tired by the end of the assessment. Therefore, if we can reduce the length of test administration even by small amounts, it may reduce fatigue in young people undergoing neuropsychological assessments. There could also be other accessibility benefits from the adapted version, including use in children with language difficulties or with English as a second language. Further exploration of using this tool in these populations would be key for improving a wide range of patient's experiences in neuropsychological testing.

The original and adapted Zoo Maps did not significantly differ in terms of number of children who discontinued the task or number of scaffolds provided by the

examiner. It is worth noting that, despite the non-significant result, no children discontinued in the adapted Zoo Map group, whereas three discontinued in the original group. Due to the underpowered nature of this study (60%) but large effect size ($OR = .109$), the adapted version may be more accessible; however, further research with a larger sample size is required. This signals towards the feasibility of this tool as more children may be able to complete it than the original version, highlighting its potential use in clinical practice. Additionally, even though the adapted Zoo Map did not require fewer prompts, it is interesting that no additional prompting was required. This suggests that reduced language demands did not compromise task comprehension, and did not lead to more discontinuation, which is an encouraging indication of the accessibility of the adapted Zoo Map. This is important to consider, as language influences EF in children more so than it does in adults due to underdeveloped language fluency and lack of vocabulary, limiting children's ability to store information in WM (Hughes & Graham, 2002). This is seen particularly in children with specific language impairments (SLI). Henry et al. (2015) tested 88 children, 41 with a SLI, on a range of verbal EF tasks. They found that children with a SLI found word retrieval and generation more challenging than controls. This highlights the need for EF assessments that reduce language load. By reducing language demands but keeping task understanding, this highlights the feasibility of the adapted Zoo Map for future research and clinical use.

Turning now to the exploratory hypotheses, we found that age scaled scores did not differ between the original and adapted versions of the Zoo Map. This suggests that the adapted version of the Zoo Map is not materially altered relative to the

original version and may have construct validity. However, this must be interpreted with caution due to the limited power of the study. As the original BADS-C has good construct validity (Fish & Wilson, 2021), this suggests that the adapted Zoo Map is also tapping into EFs such as planning. Planning could be considered a 'higher-order' EF (Miyake et al. 2000), tapping into all the EF areas posited by Friedman & Robbins (2021). These skills are theorised to become less related and more distinct as children age (Hughes et al., 2009; Lee et al., 2013). Additionally, other areas of cognition such as language and motor skills develop idiosyncratically for young people (Bjorklund, 2022), and may confound results in other areas of cognition such as EF. Therefore, the adapted Zoo Map task may provide a unique opportunity to track overall changes in EF without the confounds of language development, but further studies exploring convergent validity would be necessary.

Neither the original nor adapted Zoo Map version were strongly related to verbal comprehension, and the adapted Zoo Map was not less related to verbal comprehension than the original version. It is hard to draw conclusions from this finding due to the limited power achieved. Nevertheless, a study of 328 healthy adults aged between 18 and 93 tested on EF, reasoning, memory and vocabulary also found low correlations between EF and vocabulary (Salthouse et al., 2005). However, this depended on the task, with Listening Span and Proverb interpretation being related to vocabulary. Because of the limited sample size in the current study, further research would be required to explore the relationship between EF and language further.

Finally, the adapted Zoo Map age adjusted scores were not related to planning/organisation, CRI or GEC as measured by the parent-rated BRIEF. However,

due to the limitations in sample size, it is hard to draw any meaningful conclusions regarding this finding. A scoping review by Wallisch et al. (2018) highlighted limited correlations between EF assessments and the BRIEF. They argue that it may be that the difference in the format of the BRIEF and EF measures, as well as behaviours being exhibited and concepts being measured, that limits the BRIEF in its use for assessing veridicality. Ecological validity is important to consider in EF research with children for a number of reasons. Firstly, as highlighted by Wallisch et al. (2018), informant reports that are heavily relied upon in research often contain inconsistencies between and within raters. Additionally, scores may be biased by emotions of the rater (Chevignard et al., 2012). Therefore, behavioural measures offer an opportunity to provide a proxy for 'real-world' tasks to understand where deficits occur, and to potentially predict future behaviours and modify environments (Burgess et al., 2006). Additionally, children with epilepsy often trial a number of medications and may go on to get surgeries after diagnosis. An important part of treatment planning and monitoring the impact of interventions is through validated cognitive assessment (Baxendale, 2018). Planning, as measured by the Zoo Map, is important in everyday life for achieving educational goals and being able to engage in tasks of everyday living (Best et al., 2011). Therefore, to create an ecologically valid tool for measuring this EF would be beneficial to include in neuropsychological assessment batteries for children with epilepsy.

Strengths and Limitations

The current study introduces a novel, pictorial adaptation of the Zoo Map from the BADS-C (Emslie et al., 2003) with reduced language demands, with the aim of

improving access for children with GGE, other acquired brain injuries and the potential to be used with children with language difficulties or diversity. This study also has real-world applications, as it was completed with an NHS sample and focused on feasibility measures of the adapted Zoo Map.

The main limitation of the current research is the sample size. Initial power analysis indicated that, for a power of .8 to address the primary research question, a sample size of 42 was required. However, due to challenges recruiting participants from within a busy clinical environment, and competing research demands on the department, recruitment fell below the target assessed through initial department scoping. Recruitment challenges were addressed by expanding the range of recruiting clinicians from neurology consultants only to the wider epilepsy care team, and by adding an additional recruitment site. The small sample size increases the chances of Type II errors, with potential significant findings not identified. Additionally, because of the feasibility-focused design of this research, the exploratory analyses were severely underpowered ($n=12$ for some). Due to the significant results indicated in the feasibility measures, as well as potential construct validity, the adapted Zoo Map warrants exploration in further research with larger and potentially more diverse samples of young people.

Due to the limited sample size, the study should be considered as preliminary. Nevertheless, these initial results show promise in the use of the adapted Zoo Map with children with GGE, which may reduce time spent in neuropsychology assessment appointments. This adaptation may also be useful for other clinical samples, such as children with English as a second language (Garratt & Kelly, 2007). This may improve

equity in neuropsychological assessment for these already vulnerable populations. There are a number of challenges in cross-cultural neuropsychological assessment, including lack of norms and cultural differences in test environments. One of the largest challenges clinicians face when assessing individuals from different cultures is the language barrier (Fernández & Abe, 2018). If language was minimised, it would reduce some of the biases faced in cross cultural neuropsychology administration. Nevertheless, further research is required to further assess the psychometric properties of the adapted Zoo Map in a culturally diverse sample.

Finally, clinician effects may have also influenced the result. The clinician was not blinded to the study and therefore may have unintentionally treated the children in each condition differently. However, the clinician was also working within the department and was completing various neuropsychological assessments, learning about the importance of remaining unbiased and adhering as closely as possible to the test instructions, which potentially reduced the risk of bias.

Future Research

As alluded to above, it would be useful to use the adapted Zoo Map with larger samples with the aim of reducing Type II errors. Additionally, it would be useful to use this task with more diverse samples, including the use of typically developing children. This would allow for potential standardisation and development of normative data for the adaptation of the Zoo Map. Within this, it would be useful to explore how the non-verbal instructions are operationalised to allow for consistent use in research and clinical settings. Due to limited time constraints on this project, we were unable to collect the views of clinicians and young people on how they found the adapted Zoo

Map. Future studies may wish to gather the views of clinicians who administer EF tests regularly and incorporate their views in any revisions of the adapted Zoo Map. This should also be done with the young people receiving the test, to improve accessibility, clinical utility and engagement of future young people receiving assessment.

As with the original BADS-C (Emslie et al., 2003), it would be useful to perform the adaptation with young people with neurodevelopmental conditions such as Dyslexia and ADHD to see if it can identify clinically distinct populations to aid in diagnosis. Finally, comparing this measure to other measures of EF with veridicality and verisimilitude, such as the Multiple Errands Test (Hanberg et al., 2018), would allow a better understanding of whether the adapted Zoo Map has ecological validity and should be used in research and clinical practice.

Conclusion

To conclude, this study explored the feasibility of an adapted version of the Zoo Map subtest from the BADS-C (Emslie et al., 2003) in a sample of children with GGE. The adapted Zoo Map took significantly less time to administer the instructions compared to the original version. Although differences in discontinuation and scaffolding were not significant, overall, the findings provide initial support the potential improved accessibility of the adapted Zoo Map and its use in neuropsychological assessments. Other exploratory analyses were non-significant and severely limited by a small sample size. Despite its limitations, the study demonstrates promising initial findings and contributes to the development of inclusive assessment tools for children with epilepsy and other developmental conditions.

References

- Abarrategui, B., Parejo-Carbonell, B., García, M. E. G., Di Capua, D., & García-Morales, I. (2018). The Cognitive Phenotype of Idiopathic Generalized Epilepsy. *Epilepsy & Behavior, 89*, 99-104.
- Ahmed, S. F., Tang, S., Waters, N. E., & Davis-Kean, P. (2019). Executive Function and Academic Achievement: Longitudinal Relations from Early Childhood to Adolescence. *Journal of Educational Psychology, 111*(3), 446.
- Anderson, P. (2002). Assessment and Development of Executive Function (EF) During Childhood. *Child Neuropsychology, 8*(2), 71-82.
- Baxendale, S. (2018). Neuropsychological Assessment in Epilepsy. *Practical Neurology, 18*(1), 43-48.
- Best, J. R., & Miller, P. H. (2010). A Developmental Perspective on Executive Function. *Child Development, 81*(6), 1641-1660.
- Best, J. R., Miller, P. H., & Naglieri, J. A. (2011). Relations Between Executive function and Academic Achievement from Ages 5 to 17 in a Large, Representative National Sample. *Learning and Individual differences, 21*(4), 327-336.
- Bjorklund, D. F. (2022). *Children's Thinking: Cognitive Development and Individual Differences*. Sage Publications.
- Blakemore, S. J., & Choudhury, S. (2006). Development of the Adolescent Brain: Implications for Executive Function and Social Cognition. *Journal of Child Psychology and Psychiatry, 47*(3-4), 296-312.

- Burgess, P. W., Alderman, N., Forbes, C., Costello, A., LAURE, M. C., Dawson, D. R., ... & Channon, S. (2006). The Case for the Development and Use of “Ecologically Valid” Measures of Executive Function in Experimental and Clinical Neuropsychology. *Journal of the International Neuropsychological Society*, 12(2), 194-209.
- Chevignard, M. P., Soo, C., Galvin, J., Catroppa, C., & Eren, S. (2012). Ecological Assessment of Cognitive Functions in Children with Acquired Brain Injury: A Systematic Review. *Brain Injury*, 26(9), 1033-1057.
- Chowdhury, F. A., Elwes, R. D., Koutroumanidis, M., Morris, R. G., Nashef, L., & Richardson, M. P. (2014). Impaired Cognitive Function in Idiopathic Generalized Epilepsy and Unaffected Family Members: An Epilepsy Endophenotype. *Epilepsia*, 55(6), 835-840.
- Culhane-Shelburne, K., Chapieski, L., Hiscock, M., & Glaze, D. (2002). Executive Functions in Children with Frontal and Temporal Lobe Epilepsy. *Journal of the International Neuropsychological Society*, 8(5), 623-632.
- Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis-Kaplan Executive Function System: Technical Manual*. Harcourt Assessment Company.
- Dorris, L., Young, D., Barlow, J., Byrne, K., & Hoyle, R. (2022). Cognitive Empathy Across the Lifespan. *Developmental Medicine & Child Neurology*, 64(12), 1524-1531.
- Dunn, L. M., Dunn, D. M., Styles, B., & Sewell, J. (2009). *British Picture Vocabulary Scales III*. NFER-Nelson.

- Elger, C. E., Helmstaedter, C., & Kurthen, M. (2004). Chronic Epilepsy and Cognition. *The Lancet Neurology*, 3(11), 663-672.
- Emslie, H., Wilson, F. C., Burden, V., Nimmo-Smith, I., & Wilson, B. A. (2003). *The Behavioural Assessment of the Dysexecutive Syndrome for Children (BADS-C)*. Bury St Edmunds: Thames Valley Test Company.
- Engelhardt, L. E., Harden, K. P., Tucker-Drob, E. M., & Church, J. A. (2019). The Neural Architecture of Executive Functions is Established by Middle Childhood. *NeuroImage*, 185, 479-489.
- Fair, D. A., Dosenbach, N. U., Church, J. A., Cohen, A. L., Brahmbhatt, S., Miezin, F. M., ... & Schlaggar, B. L. (2007). Development of Distinct Control Networks through Segregation and Integration. *Proceedings of the National Academy of Sciences*, 104(33), 13507-13512.
- Fernández, A. L., & Abe, J. (2018). Bias in Cross-Cultural Neuropsychological Testing: Problems and Possible Solutions. *Culture and Brain*, 6, 1-35.
- Fish, J., & Wilson, F. C. (2021). Assessing Children's Executive Function: BADS-C Validity. *Frontiers in Psychology*, 12, 626291.
- Friedman, N. P., & Robbins, T. W. (2022). The Role of Prefrontal Cortex in Cognitive Control and Executive function. *Neuropsychopharmacology*, 47(1), 72-89.
- Garratt, L. C., & Kelly, T. P. (2007). To What Extent does Bilingualism Affect Children's Performance on the NEPSY?. *Child Neuropsychology*, 14(1), 71-81.

- Gelžinienė, G., Jurkevičienė, G., Marmienė, V., Adomaitienė, V., & Endzinienė, M. (2011). Executive Functions in Adolescents with Idiopathic Generalized Epilepsy. *Medicina (Kaunas)*, 47(6), 313-9.
- Gioia G. A., Isquith P. K., Guy S. C., Kenworthy L. (2015). *Behavior Rating Inventory of Executive Function, Second Edition (BRIEF-2)*. Lutz, FL: PAR Inc.
- Goddings, A. L., Roalf, D., Lebel, C., & Tamnes, C. K. (2021). Development of White Matter Microstructure and Executive Functions During Childhood and Adolescence: A Review of Diffusion MRI Studies. *Developmental Cognitive Neuroscience*, 51, 101008.
- Hanberg, V. L., MacKenzie, D. E., & Merritt, B. K. (2018). Scoping Review of the Multiple Errands Test: Is it Relevant to Youths with Acquired Brain Injury? *British Journal of Occupational Therapy*, 81(12), 673-686.
- Henry, L. A., Messer, D. J., & Nash, G. (2015). Executive Functioning and Verbal Fluency in Children with Language Difficulties. *Learning and Instruction*, 39, 137-147.
- Hughes, C., Ensor, R., Wilson, A., & Graham, A. (2009). Tracking Executive Function Across the Transition to School: A Latent Variable Approach. *Developmental Neuropsychology*, 35(1), 20-36.
- Hughes, C., & Graham, A. (2002). Measuring Executive Functions in Childhood: Problems and Solutions? *Child and Adolescent Mental Health*, 7(3), 131-142.
- IBM Corp. Released 2022. IBM SPSS Statistics for Windows, Version 29.0. Armonk, NY: IBM Corp.

- Jones, E. F., Pritchard, A., Jacobson, L. A., Mahone, E. M., & Zabel, T. A. (2022). How Much Testing Can a Kid Take? Feasibility of Collecting Pediatric Patient Experience Ratings of Neuropsychological and Psychological Assessment. *Applied Neuropsychology: Child*, 11(4), 610-617.
- Lee, K., Bull, R., & Ho, R. M. (2013). Developmental Changes in Executive Functioning. *Child Development*, 84(6), 1933-1953.
- Koziol, L. F., & Lutz, J. T. (2013). From Movement to Thought: The Development of Executive Function. *Applied Neuropsychology: Child*, 2(2), 104-115.
- Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The Unity and Diversity of Executive Functions and their Contributions to Complex “Frontal Lobe” Tasks: A Latent Variable Analysis. *Cognitive Psychology*, 41(1), 49-100.
- Mullen, S. A., & Berkovic, S. F. (2018). Genetic generalized epilepsies. *Epilepsia*, 59(6), 1148-1153.
- Nadebaum, C., Anderson, V., & Catroppa, C. (2007). Executive Function Outcomes Following Traumatic Brain Injury in Young Children: A Five Year Follow-Up. *Developmental Neuropsychology*, 32(2), 703-728.
- National Institute for Health and Care Excellence. (2022). *Epilepsies in Children, Young People and Adults* [NICE Guideline No. 217].
<https://www.nice.org.uk/guidance/ng217/chapter/5-Treating-epileptic-seizures-in-children-young-people-and-adults#idiopathic-generalised-epilepsies>

- Operto, F. F., Pastorino, G. M. G., Mazza, R., Carotenuto, M., Roccella, M., Marotta, R., ... & Verrotti, A. (2020). Effects on Executive Functions of Antiepileptic Monotherapy in Pediatric age. *Epilepsy & Behavior*, 102, 106648.
- Otero, T. M., Barker, L. A., & Naglieri, J. A. (2014). Executive Function Treatment and Intervention in Schools. *Applied Neuropsychology: Child*, 3(3), 205-214.
- Ratcliffe, C., Wandschneider, B., Baxendale, S., Thompson, P., Koepp, M. J., & Caciagli, L. (2020). Cognitive Function in Genetic Generalized Epilepsies: Insights from Neuropsychology and Neuroimaging. *Frontiers in Neurology*, 11, 144.
- Rathouz, P. J., Zhao, Q., Jones, J. E., Jackson, D. C., Hsu, D. A., Stafstrom, C. E., ... & Hermann, B. P. (2014). Cognitive Development in Children with New Onset Epilepsy. *Developmental Medicine & Child Neurology*, 56(7), 635-641.
- Reuner, G., Kadish, N. E., Doering, J. H., Balke, D., & Schubert-Bast, S. (2016). Attention and Executive Functions in the Early Course of Pediatric Epilepsy. *Epilepsy & Behavior*, 60, 42-49.
- Robertson, K., & Schmitter-Edgecombe, M. (2017). Naturalistic Tasks Performed in Realistic Environments: A Review with Implications for Neuropsychological Assessment. *The Clinical Neuropsychologist*, 31(1), 16-42.
- Rocke, K., Hays, P., Edwards, D., & Berg, C. (2008). Development of a Performance Assessment of Executive Function: The Children's Kitchen Task Assessment. *The American Journal of Occupational Therapy*, 62(5), 528-537.

- Romundstad, B., Solem, S., Brandt, A. E., Hypher, R. E., Risnes, K., Rø, T. B., ... & Finnanger, T. G. (2023). Validity of the Behavioural Assessment of the Dysexecutive Syndrome for Children (BADS-C) in Children and Adolescents with Pediatric Acquired Brain Injury. *Neuropsychological Rehabilitation*, 33(4), 551-573.
- Salthouse, T. A. (2005). Relations Between Cognitive Abilities and Measures of Executive Functioning. *Neuropsychology*, 19(4), 532-545.
- Sepeta, L. N., Casaletto, K. B., Terwilliger, V., Facella-Ervolini, J., Sady, M., Mayo, J., ... & Berl, M. M. (2017). The Role of Executive Functioning in Memory Performance in Pediatric Focal Epilepsy. *Epilepsia*, 58(2), 300-310.
- Shokrkon, A., & Nicoladis, E. (2022). The Directionality of the Relationship Between Executive Functions and Language Skills: A Literature Review. *Frontiers in Psychology*, 13, 848696.
- Stålhammar, J., Hellström, P., Eckerström, C., & Wallin, A. (2022). Neuropsychological Test Performance Among Native and Non-Native Swedes: Second Language Effects. *Archives of Clinical Neuropsychology*, 37(4), 826-838.
- Suchy, Y. (2009). Executive Functioning: Overview, Assessment, and Research Issues for Non-Neuropsychologists. *Annals of Behavioral Medicine*, 37(2), 106-116.
- Suchy, Y., DesRuisseaux, L. A., Mora, M. G., Brothers, S. L., & Niermeyer, M. A. (2024). Conceptualization of the Term “Ecological Validity” in Neuropsychological Research on Executive Function Assessment: A Systematic Review and Call to Action. *Journal of the International Neuropsychological Society*, 30(5), 499-522.

- Symonds, J. D., Elliott, K. S., Shetty, J., Armstrong, M., Brunklaus, A., Cutcutache, I., ... & Zuberi, S. M. (2021). Early Childhood Epilepsies: Epidemiology, Classification, Aetiology, and Socio-Economic Determinants. *Brain*, 144(9), 2879-2891.
- Tucker-Drob, E. M. (2009). Differentiation of Cognitive Abilities Across the Life Span. *Developmental Psychology*, 45(4), 1097.
- Wallisch, A., Little, L. M., Dean, E., & Dunn, W. (2018). Executive Function Measures for Children: A Scoping Review of Ecological Validity. *OTJR: Occupation, Participation and Health*, 38(1), 6-14.
- Wechsler D. (2011). *Wechsler Abbreviated Scale of Intelligence—Second Edition (WASI-II)*. San Antonio, TX: NCS Pearson.
- Wilson, B. A., Alderman, N., Burgess, P. W., Emslie, H., & Evans, J. J. (1996). *Behavioural Assessment of the Dysexecutive Syndrome*. Bury St Edmunds, UK: Harcourt Assessment.
- Wirrell, E. C., Grossardt, B. R., Wong-Kisiel, L. C., & Nickels, K. C. (2011). Incidence and Classification of New-Onset Epilepsy and Epilepsy Syndromes in Children in Olmsted County, Minnesota from 1980 to 2004: A Population-Based Study. *Epilepsy Research*, 95(1-2), 110-118.
- Yang, Y., Shields, G. S., Zhang, Y., Wu, H., Chen, H., & Romer, A. L. (2022). Child Executive Function and Future Externalizing and Internalizing Problems: A Meta-Analysis of Prospective Longitudinal Studies. *Clinical Psychology Review*, 97, 102194.

Appendix 1 – Search Strategies for Databases Searched

Medline Search Strategy

1 exp Epilepsy/

2 exp Seizures/

3 (epilep\$ or seizure\$ or convuls\$).tw.

4 exp child/

5 child\$.ti,ab.

6 adolescen\$.ti,ab.

7 school age.ti,ab.

8 minor.ti,ab.

9 boy.ti,ab.

10 girl.ti,ab.

11 young people.ti,ab.

12 young person.ti,ab.

13 p#ediatric.ti,ab.

14 exp attention/

15 attention.ti,ab.

16 concentration.ti,ab.

17 exp executive function/

18 executive funct*.ti,ab.

19 executive dysfunct*.ti,ab.

20 organi*.ti,ab.

21 flexib*.ti,ab.
22 shifting.ti,ab.
23 planning.ti,ab.
24 exp decision making/
25 decision making.ti,ab.
26 cognitive control.ti,ab.
27 inhibit*.ti,ab.
28 exp memory/
29 memory.ti,ab.
30 exp problem solving/
31 problem solv*.ti,ab.
32 reasoning.ti,ab.
33 exp processing speed/
34 processing speed.ti,ab.
35 speed of processing.ti,ab.
36 fluency.ti,ab.
37 coding.ti,ab.
38 exp language/
39 language.ti,ab.
40 naming.ti,ab.
41 exp reading/
42 reading.ti,ab.

43 exp comprehension/

44 comprehension.ti,ab.

45 exp mental recall/

46 mental recall.ti,ab.

47 exp cognition/

48 cogniti*.ti,ab.

49 exp neuropsychology/

50 neuropsycholog*.ti,ab.

51 intervention.ti,ab.

52 exp rehabilitation/

53 rehabilitation.ti,ab.

54 remediation.ti,ab.

55 training.ti,ab.

56 1 or 2 or 3

57 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13

58 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28

or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or

43 or 44 or 45 or 46 or 47 or 48 or 49 or 50

59 51 or 52 or 53 or 54 or 55

60 56 and 57 and 58 and 59

Embase Search Strategy

- 1 exp Epilepsy/
- 2 exp Seizures/
- 3 (epilep\$ or seizure\$ or convuls\$).tw.
- 4 exp child/
- 5 child\$.ti,ab.
- 6 adolescen\$.ti,ab.
- 7 school age.ti,ab.
- 8 minor.ti,ab.
- 9 boy.ti,ab.
- 10 girl.ti,ab.
- 11 young people.ti,ab.
- 12 young person.ti,ab.
- 13 p#ediatric.ti,ab.
- 14 exp attention/
- 15 attention.ti,ab.
- 16 concentration.ti,ab.
- 17 exp executive function/
- 18 executive funct*.ti,ab.
- 19 executive dysfunct*.ti,ab.
- 20 exp organisation/
- 21 organi*.ti,ab.

22 exp cognitive flexibility/
23 flexib*.ti,ab.
24 shifting.ti,ab.
25 exp planning/
26 planning.ti,ab.
27 exp decision making/
28 decision making.ti,ab.
29 cognitive control.ti,ab.
30 inhibit*.ti,ab.
31 exp memory/
32 memory.ti,ab.
33 exp problem solving/
34 problem solv*.ti,ab.
35 exp reasoning/
36 reasoning.ti,ab.
37 exp processing speed/
38 processing speed.ti,ab.
39 speed of processing.ti,ab.
40 fluency.ti,ab.
41 exp coding/
42 coding.ti,ab.
43 exp language/

44 language.ti,ab.

45 naming.ti,ab.

46 exp reading/

47 reading.ti,ab.

48 exp comprehension/

49 comprehension.ti,ab.

50 exp recall/

51 mental recall.ti,ab.

52 exp cognition/

53 cogniti*.ti,ab.

54 exp neuropsychology/

55 neuropsycholog*.ti,ab.

56 intervention.ti,ab.

57 exp rehabilitation/

58 rehabilitation.ti,ab.

59 remediation.ti,ab.

60 exp training/

61 training.ti,ab.

62 1 or 2 or 3

63 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13

64 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28

or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or

43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55

65 56 or 57 or 58 or 59 or 60 or 61

66 62 and 63 and 64 and 65

CINAHL Search Strategy

1 (MH "Epilepsy+")

2 (MH "seizures+")

3 TI epilep* OR AB epilep* OR TI seizure* OR AB seizure* OR TI convuls* OR AB convuls*

4 (MH "Child+")

5 (MH "Adolescence+")

6 TI child* OR AB child*

7 TI adolescen* OR AB adolescen*

8 TI school age OR AB school age

9 TI minor OR AB minor

10 TI boy OR AB boy

11 TI girl OR AB girl

12 TI "young people" OR AB "young people"

13 TI "young person" OR AB "young person"

14 TI p?ediatric OR AB p?ediatric

15 (MH "Attention+")

16 TI attention OR AB attention

17 TI concentration OR AB concentration

18 (MH "Executive Function")

19 TI "executive funct*" OR AB "executive funct"

20 TI "executive dysfunct*" OR AB "executive dysfunct"

21 TI organi* OR AB organi*

22 (MH "Cognitive Flexibility")

23 TI flexib* OR AB flexib*

24 TI shifting OR AB shifting

25 TI planning OR AB planning

26 (MH "Decision Making+")

27 TI "decision making" OR AB "decision making"

28 TI "cognitive control" OR AB "cognitive control"

29 TI inhibit* OR AB inhibit*

30 (MH "Memory+")

31 TI memory OR AB memory

32 (MH "Problem Solving+")

33 TI "problem solv*" OR AB "problem solv"

34 TI reasoning OR AB reasoning

35 (MH "Processing Speed")

36 TI "processing speed" OR AB "processing speed"

37 TI "speed of processing" OR AB "speed of processing"

- 38 TI fluency OR AB fluency
- 39 (MH "Coding+")
- 40 TI coding OR AB coding
- 41 (MH "Language+")
- 42 TI language OR AB language
- 43 TI naming OR AB naming
- 44 (MH "Reading+")
- 45 TI reading OR AB reading
- 46 TI comprehension OR AB comprehension
- 47 TI "mental recall" OR AB "mental recall"
- 48 (MH "Cognition+")
- 49 TI cogniti* OR AB cogniti*
- 50 (MH "Neuropsychology")
- 51 TI neuropsycholog* OR AB neuropsycholog*
- 52 TI intervention OR AB intervention
- 53 (MH "Rehabilitation+")
- 54 TI rehabilitation OR AB rehabilitation
- 55 (MH "Cognitive Remediation")
- 56 TI remediation OR AB remediation
- 57 TI training OR AB training
- 58 1 or 2 or 3
- 59 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14

60 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29
or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or
44 or 45 or 46 or 47 or 48 or 49 or 50 or 51
61 52 or 53 or 54 or 55 or 56 or 57
62 58 and 59 and 60 and 61

PsycINFO Search Strategy

1 DE "Epilepsy" OR DE "Epileptic Seizures" OR DE "Experimental Epilepsy" OR DE
"Lennox Gastaut Syndrome"

2 DE "Seizures" OR DE "Audiogenic Seizures" OR DE "Epileptic Seizures" OR DE
"Grand Mal Seizures" OR DE "Petit Mal Seizures" OR DE "Status Epilepticus"

3 TI epilep* OR AB epilep* OR TI seizure* OR AB seizure* OR TI convuls* OR AB
convuls*

4 TI child* OR AB child*

5 TI adolescen* OR AB adolescen*

6 TI school age OR AB school age

7 TI minor OR AB minor

8 TI boy OR AB boy

9 TI girl OR AB girl

10 TI "young people" OR AB "young people"

11 TI "young person" OR AB "young person"

12 TI p?ediatric OR AB p?ediatric

13 DE "Attention" OR DE "Attentional Capture" OR DE "Distraction" OR DE "Divided
Attention" OR DE "Focused Attention" OR DE "Monitoring" OR DE "Selective
Attention" OR DE "Sustained Attention" OR DE "Vigilance" OR DE "Visual
Attention"

14 TI attention OR AB attention

15 DE "Concentration"

16 TI concentration OR AB concentration

17 DE "Executive Function" OR DE "Cognitive Control" OR DE "Set Shifting" OR DE
"Task Switching"

18 TI "executive funct*" OR AB "executive funct*"

19 TI "executive dysfunct*" OR AB "executive dysfunct*"

20 TI organi* OR AB organi*

21 DE "Cognitive Flexibility"

22 TI flexib* OR AB flexib*

23 TI shifting OR AB shifting

24 TI planning OR AB planning

25 DE "Decision Making" OR DE "Choice Behavior" OR DE "Ethical Decision Making"
OR DE "Group Decision Making" OR DE "Management Decision Making" OR DE
"Uncertainty"

26 TI "decision making" OR AB "decision making"

27 DE "Cognitive Control"

28 TI "cognitive control" OR AB "cognitive control"

29 TI inhibit* OR AB inhibit*

30 DE "Memory" OR DE "Associative Memory" OR DE "Autobiographical Memory"

OR DE "Collective Memory" OR DE "Early Memories" OR DE "Eidetic Imagery" OR

DE "Episodic Memory" OR DE "Explicit Memory" OR DE "False Memory" OR DE

"Forgetting" OR DE "Implicit Memory" OR DE "Long Term Memory" OR DE

"Memory Consolidation" OR DE "Memory Decay" OR DE "Memory Trace" OR DE

"Prospective Memory" OR DE "Reminiscence" OR DE "Repressed Memory" OR

DE "Retrospective Memory" OR DE "Short Term Memory" OR DE "Spatial

Memory" OR DE "Spontaneous Recovery (Learning)" OR DE "Tip of the Tongue

Phenomenon" OR DE "Verbal Memory" OR DE "Visual Memory"

31 TI memory OR AB memory

32 DE "Problem Solving" OR DE "Anagram Problem Solving" OR DE "Cognitive

Hypothesis Testing" OR DE "Group Problem Solving" OR DE "Heuristics" OR DE

"Word Problem"

33 TI "problem solv*" OR AB "problem solv*"

34 DE "Reasoning" OR DE "Case Based Reasoning" OR DE "Dialectics" OR DE

"Inductive Deductive Reasoning"

35 TI reasoning OR AB reasoning

36 DE "Cognitive Processing Speed"

37 TI "processing speed" OR AB "processing speed"

38 TI "speed of processing" OR AB "speed of processing"

39 DE "Verbal Fluency"

40 TI fluency OR AB fluency

41 TI coding OR AB coding

42 DE "Language" OR DE "Dialect" OR DE "Figurative Language" OR DE "Foreign Languages" OR DE "Form Classes (Language)" OR DE "Interpreters" OR DE "Monolingualism" OR DE "Multilingualism" OR DE "Names" OR DE "Native Language" OR DE "Natural Language" OR DE "Phrases" OR DE "Profanity" OR DE "Reading" OR DE "Rhetoric" OR DE "Sentences" OR DE "Sign Language" OR DE "Spelling" OR DE "Vocabulary" OR DE "Written Language"

43 TI language OR AB language

44 DE "Naming"

45 TI naming OR AB naming

46 DE "Reading" OR DE "Braille" OR DE "Oral Reading" OR DE "Remedial Reading" OR DE "Silent Reading"

47 TI reading OR AB reading

48 DE "Comprehension" OR DE "Number Comprehension" OR DE "Verbal Comprehension"

49 TI comprehension OR AB comprehension

50 TI "mental recall" OR AB "mental recall"

51 DE "Cognition" OR DE "Animal Cognition" OR DE "Mental Lexicon" OR DE "Mind Wandering" OR DE "Neurocognition"

52 TI cogniti* OR AB cogniti*

53 DE "Neuropsychology"

54 TI neuropsycholog* OR AB neuropsycholog*

55 DE "Intervention" OR DE "Crisis Intervention" OR DE "Early Intervention" OR DE
"Family Intervention" OR DE "Group Intervention" OR DE "School Based
Intervention" OR DE "Workplace Intervention"

56 TI intervention OR AB intervention

57 DE "Rehabilitation" OR DE "Criminal Rehabilitation" OR DE "Language Therapy"
OR DE "Neurorehabilitation" OR DE "Occupational Therapy" OR DE "Physical
Therapy" OR DE "Psychosocial Rehabilitation" OR DE "Speech Therapy" OR DE
"Telerehabilitation"

58 TI rehabilitation OR AB rehabilitation

59 DE "Cognitive Remediation"

60 TI remediation OR AB remediation

61 DE "Training" OR DE "Assertiveness Training" OR DE "Athletic Training" OR DE
"Autogenic Training" OR DE "Biofeedback Training" OR DE "Childbirth Training"
OR DE "Clinical Methods Training" OR DE "Communication Skills Training" OR
DE "Computer Training" OR DE "Cross Cultural Training" OR DE "Diversity
Training" OR DE "Human Relations Training" OR DE "Memory Training" OR DE
"Military Training" OR DE "Motivation Training" OR DE "Parent Training" OR DE
"Personnel Training" OR DE "Self-Instructional Training" OR DE "Sensitivity
Training" OR DE "Social Skills Training" OR DE "Toilet Training" OR DE "Work

Adjustment Training"

62 TI training OR AB training

63 1 or 2 or 3

64 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12

65 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27

or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or

42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54

66 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62

67 63 and 64 and 65 and 66

Appendix 2 – Ratings of each study using the QualSyst Risk of Bias Tool

[illegible]

Outcome measures	2	2	2	2	1	1	1	1	2	2	2	2
Sample size	2	2	1	1	1	1	1	1	1	1	1	1
Analytic methods	2	2	2	2	1	1	1	1	2	2	2	2
Estimate of variance	2	2	2	1	2	1	1	1	1	2	2	1
Confounding	2	2	0	2	0	2	0	0	1	2	0	1
Results	2	2	2	2	1	2	1	1	2	2	1	1
Conclusions	2	2	2	2	1	2	1	1	2	2	1	1

Appendix 3 – PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	p11
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	p12-13
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	p14-18
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	p18-19
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	p19-20
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	p20
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	p91-105
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	p20-21
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	p21
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	p21
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	p21
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	p21
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	p22
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	p22
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	p22
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	p22

Section and Topic	Item #	Checklist item	Location where item is reported
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	p22
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	p22
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	p22
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	p41
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	p41
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	p23
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	p23
Study characteristics	17	Cite each included study and present its characteristics.	p24-28
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	p20-21
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	p29-30
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	p24-28
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	N/A
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	p36-39
	23b	Discuss any limitations of the evidence included in the review.	p41-42
	23c	Discuss any limitations of the review processes used.	p41-42
	23d	Discuss implications of the results for practice, policy, and future research.	p39-41

Section and Topic	Item #	Checklist item	Location where item is reported
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	p13
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	p20
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	p20
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	p42
Competing interests	26	Declare any competing interests of review authors.	p42
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

Appendix 4 – PRISMA 2020 Abstract Checklist

Section and Topic	Item #	Checklist item	Reported (Yes/No)
TITLE			
Title	1	Identify the report as a systematic review.	Yes
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	Yes
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	Yes
Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	Yes
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	Yes
Synthesis of results	6	Specify the methods used to present and synthesise results.	Yes
RESULTS			
Included studies	7	Give the total number of included studies and participants and summarise relevant characteristics of studies.	Yes
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured).	Yes
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	Yes
Interpretation	10	Provide a general interpretation of the results and important implications.	Yes
OTHER			
Funding	11	Specify the primary source of funding for the review.	Yes
Registration	12	Provide the register name and registration number.	Yes

Appendix 5 – Description of the adapted Zoo Map

The adapted Zoo Map is adapted from the Zoo Map subtest of the Behavioural Assessment of the Dysexecutive Syndrome for Children (BADS-C; Emslie et al., 2003). The first part of the task provides children with a map of a zoo with several pictures of different animals to visit, such as elephants and lions. Certain paths on the map are shaded, whereas others are white. Children are also provided with some 'rules' they have to follow, including:

- Certain animals/places they have to visit.
- Paths they can only use once.
- Where they must start and end the task.

The following instructions are provided to the child:

- Here is a zoo
- You have to draw a plan to visit these animals
- Follow these instructions

The young person was given time to go through the instructions as many times as necessary. The examiner also pointed to the corresponding items on the map, such as the camels and the shaded areas, as necessary, but language is kept to a minimum. This task is timed until the child completes the task, or they discontinue.

In the second part of the task, the same map is presented to the child, but the instructions reveal the optimal route for them to take. The same instructions are provided and the task is timed.

Appendix 6 – NHS Greater Glasgow and Clyde Board Approval to Conduct Research

NHS GG&C Board Approval

Dear Miss Rachael Aitken

Study Title:	The accessibility of an adapted version of the Zoo Map subtest of the Behavioural Assessment of the Dysexecutive Syndrome for Children (BADS-C) in a paediatric epilepsy sample
Principal Investigator:	Miss Rachael Aitken
GG&C HB site	Royal Hospital for Sick Children (Glasgow)
Sponsor	University of Glasgow
R&I reference:	UGN24NE110P
REC reference:	24/NS/0037
Protocol no: (including version and date)	V9 29/02/2024

I am pleased to confirm that Greater Glasgow & Clyde Health Board is now able to grant **Approval** for the above study.

Conditions of Approval

1. **For Clinical Trials** as defined by the Medicines for Human Use Clinical Trial Regulations, 2004
 - a. During the life span of the study GGHB requires the following information relating to this site
 - i. Notification of any potential serious breaches.
 - ii. Notification of any regulatory inspections.

It is your responsibility to ensure that all staff involved in the study at this site have the appropriate GCP training according to the GGHB GCP policy (www.nhsggc.org.uk/content/default.asp?page=s1411), evidence of such training to be filed in the site file. Researchers must follow NHS GG&C local policies, including incident reporting.

2. **For all studies** the following information is required during their lifespan.
 - a. First study participant should be recruited within 30 days of approval date.
 - b. Recruitment Numbers on a monthly basis
 - c. Any change to local research team staff should be notified to R&I team
 - d. Any amendments – Substantial or Non Substantial
 - e. Notification of Trial/study end including final recruitment figures

Page 1 of 2

letter



- f. Final Report & Copies of Publications/Abstracts

- g. You must work in accordance with the current NHS GG&C COVID19 guidelines and principles.

Please add this approval to your study file as this letter may be subject to audit and monitoring.

Your personal information will be held on a secure national web-based NHS database.

I wish you every success with this research study

Appendix 7 - NHS Lothian Board Approval to Conduct Research

NHS Lothian R&D Management Approval

Lothian R&D No: 2025/0031

REC No: 24/NS/0037

Title of Research: The accessibility of an adapted version of the Zoo Map subtest of the Behavioural Assessment of the Dysexecutive Syndrome for Children (BADS-C) in children with epilepsy

Approved Location(s) within NHS Lothian: Royal Hospital for Children & Young People

Approved Documents	Version	Date
Protocol	13.0	16 th December 2024
Participant Information Sheet:		
Parent	8.0	16 th December 2024
13-15yrs	6.0	16 th December 2024
8-12yrs	6.0	16 th December 2024
Consent Form:		
Parent - Child Assent (8-12yrs)	4.0	7 th March 2025
Parent Assent (12-15yrs)	4.0	7 th March 2025
Parent	6.0	7 th March 2025
Child	5.0	7 th March 2025

I am pleased to inform you this letter provides Site Specific approval for NHS Lothian for the above study and you may proceed with your research, subject to the conditions below.



Headquarters
Waverley Gate
2-4 Waterloo Place
Edinburgh EH1 3EG

Chair Professor John Cunningham CBE
Chief Executive Professor Caroline Hince
Lothian NHS Board is the common
name of Lothian Health Board



Please note that the NHS Lothian R&D Office must be informed of any changes to the study such as amendments to the protocol, funding, recruitment, personnel or resource input required of NHS Lothian.

Substantial amendments to the protocol will require approval from the ethics committee which approved your study and the MHRA where applicable.

Data controllers and processors have a legal obligation to hold a register of all their information assets (e.g. personal information (data) and/or special categories of personal data held in paper or electronic format for the purpose of clinical research). This R&D management approval is given on the understanding that:

- You, as a potential information asset owner, will register any information assets associated with this research project with your employing organisation (where the data is held) in accordance with the Data Protection Act 2018.
- The personal data processed is only to be used for the study in question and in accordance with the study protocol, participant information sheet and consent form (where applicable).
- Personal data is processed and stored securely and in compliance with study specific data processing agreements.

Please keep this office informed of the following study information, **which is a condition of NHS Lothian R&D Management Approval:**

- Date you are ready to begin recruitment, date of the recruitment of the first participant and the monthly recruitment figures thereafter.
- Date the final participant is recruited and the final recruitment figures.
- Date your study / trial is completed within NHS Lothian.

Appendix 8 - North of Scotland Research Ethics Committee Approval

Dear Dr Fish

Study title:	The accessibility of an adapted version of the Zoo Map subtest of the Behavioural Assessment of the Dysexecutive Syndrome for Children (BADS-C) in children with epilepsy
REC reference:	24/NS/0037
IRAS project ID:	337852

Thank you for your letter of 10 June 2024, responding to the Research Ethics Committee's (REC) 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

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.

Appendix 9 – North of Scotland Research Ethics Committee Substantial Amendment Approval

Dear Miss Aitken

Study title: The accessibility of an adapted version of the Zoo Map subtest of the Behavioural Assessment of the Dysexecutive Syndrome for Children (BADS-C) in children with epilepsy
REC reference: 24/NS/0037
Amendment number: SA02 17.10.2024
Amendment date: 17 October 2024
IRAS project ID: 337852

The above amendment was by the Sub-Committee in correspondence.

Ethical opinion

The members of the Committee taking part in the review gave a favourable ethical opinion of the amendment on the basis described in the notice of amendment form and supporting documentation.

Approved documents

The documents reviewed and approved at the meeting were:

Document	Version	Date
Completed Amendment Tool - IRAS 337852 SA02 17.10.2024 Amendment Tool	1	17 October 2024
Participant consent form - Child assent form v3 15-10-24 IRAS ID 337852	3	15 October 2024
Participant consent form - Child assent form v3 15-10-24 IRAS ID 337852 TRACK CHANGES	3	15 October 2024
Participant consent form - Child consent form v5 15-10-24 IRAS ID 337852	5	15 October 2024
Participant consent form - Child consent form v5 15-10-24 IRAS ID 337852 TRACK CHANGES	5	15 October 2024
Participant consent form - Parent assent form v3 15-10-24 IRAS ID 337852	3	15 October 2024

Participant consent form - Parent consent form v5 15-10-24 IRAS ID 337852	5	15 October 2024
Participant consent form - Parent assent form v3 15-10-24 IRAS ID 337852 TRACK CHANGES	3	15 October 2024
Participant consent form - Parent consent form v5 15-10-24 IRAS ID 337852 TRACK CHANGES	5	15 October 2024
Participant information sheet - YP 13-15 v5 15-10-24 IRAS ID 337852	5	15 October 2024
Participant information sheet - YP 13-15 v5 15-10-24 IRAS ID 337852 TRACK CHANGES	5	15 October 2024
Participant information sheet - Parent v7 15-10-24 IRAS ID 337852	7	15 October 2024
Participant information sheet - Parent v7 15-10-24 IRAS ID 337852 TRACK CHANGES	7	15 October 2024
Participant information sheet - Young Person 8-12 Years Old	5	15 October 2024
Research protocol or project proposal - Study protocol v11 15.10.24 IRAS ID 337852	11	15 October 2024
Research protocol or project proposal - Study protocol v11 15.10.24 IRAS ID 337852 TRACK CHANGES	11	15 October 2024

Appendix 10 – Demographics Questionnaire



The accessibility of an adapted version of the Zoo Map subtest of the Behavioural Assessment of the Dysexecutive Syndrome for Children (BADS-C) in children with epilepsy

Demographics Questionnaire

As part of the study, we would like to know some information about your child to help us understand more about them and their epilepsy. Please answer the following questions in relation to your child. If you have any questions, or are unsure how to answer, please speak to Rachael.

Study ID Number				
Age (Years and Months)				
Gender				
Epilepsy diagnosis				
Date of diagnosis				
How many medications does your child currently take for their epilepsy? What are they?				
What is your child's current seizure frequency?	Daily	Weekly	Monthly	More than monthly

Appendix 11 – Comparisons of Demographic and Clinical Variables based on Zoo Map Version

Demographic	Test Used	Result
<i>Age</i>	Mann-Whitney U	U = 52, n = 24, p = .248, d = .485
<i>Gender</i>	Fisher's Exact Test	p = 1.000
<i>Verbal Comprehension (BPVS)</i>	t-test	t(22) = -.113, p = .911, d = -.046
<i>IQ</i>	Mann-Whitney U	U = 71, n = 24, p = .954, d = .024
<i>Seizure frequency</i>	Fisher's Exact Test	p = .500
<i>Length of diagnosis</i>	Mann-Whitney U	U = 59.5, n = 24, p = .468, d = .298
<i>Number of AEDs</i>	Fisher's Exact Test	p = .387

Appendix 12 – STROBE Reporting Checklist

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	53	"A feasibility study exploring the accessibility of an adapted, primarily pictorial, version of the Zoo Map subtest from the Behavioural Assessment of the Dysexecutive Syndrome for Children (Emslie et al., 2003). "
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	53-54	
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	p55-62	
Objectives	3	State specific objectives, including any prespecified hypotheses	p63	
Methods				
Study design	4	Present key elements of study design early in the paper	p64	
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	p65	
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	p65	

		<i>Case-control study</i>—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i>—Give the eligibility criteria, and the sources and methods of selection of participants		
		(b) <i>Cohort study</i>—For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i>—For matched studies, give matching criteria and the number of controls per case	N/A	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	p66-67	
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	p66-68	
Bias	9	Describe any efforts to address potential sources of bias	p64	“Participants were pseudo-randomly assigned to either the original or adapted Zoo Map condition using a Latin Square. Group allocation was based on age, split by 2-year epochs, and verbal comprehension (below average <90; average 90-110; above average >110 as determined by results of the BPVS) to ensure, as far as possible, that the experiments groups were balanced on these variables”

Study size	10	Explain how the study size was arrived at	p64	“To obtain 80% power to detect large effects (Cohen’s $d=.8$), where $p=0.05$, for hypotheses 1.2 and 1.3, a sample size of 42 (21 in each group) was required. Due to limitations with data collection, including clinical demand and limited recruitment period, this sample size was not met, with 24 being recruited. This reduced sample size gave only 60% power to detect equivalent effects.”
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Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	p69-70
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	p69-70
		(b) Describe any methods used to examine subgroups and interactions	N/A
		(c) Explain how missing data were addressed	p134
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed	p134
		<i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	
		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	p70
		(b) Give reasons for non-participation at each stage	p70
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	p71
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	N/A

Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	p70-73
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	p70-73
		(b) Report category boundaries when continuous variables were categorized	N/A
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A

Continued on next page

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	p73-74
Discussion			
Key results	18	Summarise key results with reference to study objectives	p74-78
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	p79-80
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	p81-82
Generalisability	21	Discuss the generalisability (external validity) of the study results	p80-81
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	N/A

Appendix 13 – Approved MRP Proposal

<https://osf.io/nxf27>

Appendix 14 – Information Sheets and Consent Forms

- Information sheet for young people aged 8-12: <https://osf.io/aqmpz>
- Information sheet for young people aged 13-15: <https://osf.io/bvre2>
- Information sheet for parents: <https://osf.io/75r2a>
- Parent consent form: <https://osf.io/qk86t>
- Parent assent form: <https://osf.io/4mvhx>
- Child consent form: <https://osf.io/2sgq7>
- Child assent form: <https://osf.io/fyrm9>

Appendix 15 – Data Analysis Plan

<https://osf.io/g2yh8>

Appendix 16 – SPSS annotated syntax

<https://osf.io/q8pze>

Appendix 17 – Data Availability Statement

Due to difficulties with recruitment and the underpowered nature of the study, discussions are ongoing regarding whether data will be made openly available via Enlighten, or whether data will be stored with restricted access that could be made available upon request to the project team.