

The Australian EEG Database

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Key Words

Absence Epilepsy
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Entropy
QEEG

ABSTRACT

The Australian EEG Database is a web-based de-identified searchable database of 18,500 EEG records recorded at a regional public hospital over an 11-year period. Patients range in age from a premature infant born at 24 weeks gestation, through to people aged over 90 years. This paper will describe the history of the database, the range of patients represented in the database, and the nature of the text-based and digital data contained in the database. Preliminary results of the first two studies undertaken using the database are presented. Plans for sharing data from the Australian EEG database with researchers are discussed.

We anticipate that such data will be useful in not only helping to answer clinical questions but also in the field of mathematical modeling of the EEG.

INTRODUCTION

The Australian EEG Database (AED) project began in 2001 as a collaboration between staff from the University of Newcastle and the John Hunter Hospital (JHH). The JHH is a regional teaching hospital with a stable and homogenous referral base as well as a trend of long staff tenure. It opened in 1991, with one of the first digital EEG machines in Australia, still operating, and using the same EEG collection protocols. The resulting EEG data of some 18,500 patients form the basis of the Australian EEG Database. We will discuss some AED history, describe the dataset and show some preliminary results from the first two studies (developmental language disorders; absence epilepsy) undertaken using the database. Plans for sharing this database with researchers worldwide will be outlined.

THE JOHN HUNTER HOSPITAL EEG DATABASE (JHED)

The JHH Department of Neurophysiology has recorded all EEGs on a Walter Graphtek Paperless EEG system. This stores text-based data and EEG data separately. Demographics, clinical history, technician's notes and neu-

rologist's report for each patient are stored through a DOS-based Btrieve database system. This system only allows for searches for a particular patient of interest, based on medical record number, name or date of birth. EEG data were recorded using 3 common montages (neonate, infant and adult) and stored on optical disk. The EEGs were recorded using bipolar connections and standard International System 10-20 electrode placements. Recording was undertaken in the resting state with eyes open and eyes closed, and if clinically indicated, conditions of hyperventilation and photic stimulation were also used. Upon request, some recordings were taken after sleep-deprivation. During EEG interpretation, the clinician could choose among a variety of standard electrode connections (including sagittal, coronal, peri-frontal and peri-occipital)

Our project was devised in 2001 and aimed to transform this dataset into an online searchable, extendable database with viewing, export and analysis features. This involved transferring text-based data to a modern database system, archiving EEG data files from their existing optical disk format onto a server and then writing software that would allow the EEG records to be viewed, marked, and exported for analysis. This process took 2 years to complete and has resulted in the online Australian EEG Database.

THE AUSTRALIAN EEG DATABASE

The Australian EEG Database is a secure web-based searchable database. The web interface incorporates a sign-on procedure assigning various levels of user access (Administrator, Analyst, Researcher, and Student). Users can be assigned to groups that can be moderated by a Chief Investigator and will also allow correspondence between researchers regarding records of interest.

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Table 1	
Possible query fields (any and all combinations)	
Field name	Description
Record ID	A number identifying the record in the database
Age at EEG	Age in years and months
Length of EEG	hh/mm/ss
Sex	Male/Female
Handedness	R/L/Ambidextrous
Medication	Current medications, including any sedation
Last Event	As reported to technician
Last Meal	As reported to technician
Referral source	Inpatient/OP/neurologist/GP/other
Technician	Technician's code number
History	As provided on referral form
Technician's comments	Technician's comments on patient's behavior during EEG
Previous EEG	Comments and reference to any previous EEGs for this patient
Report	Full report on EEG by neurologist

Text Data

The Web-based database contains the searchable fields listed in Table 1. It is important to note that all records appearing in the database appear as very stringently de-identified. (Figure 1) Users can construct, review, alter and save queries. When they have created a patient set of interest, they can then select "order CD," and a CD will be compiled of their records of interest, together with the EEG viewing software. EEGs may also be viewed online.

EEG Viewer

This application allows for the standard visual inspection of the EEG, as well as for marking and exporting sections of the record for analysis (Figure 2).

Patient Groups Represented in the Database

The database contains EEG records for premature babies through to an adult of 98 years (Figure 3). A strength of the Australian EEG Database is the number of records it holds for babies and children, as shown in Figure 4.

As many patients are referred for EEG investigation with a low probability of disease, many normal EEGs are included in the database. The database does include a unique series of 42 records from carefully screened normal neonates born between 24 and 44 weeks of gestation. The database can be searched to find records of interest, such as a particular condition (see Table 2 for some examples). Database users are able to construct searches for patient

groups by searching for terms contained in the history and referral question.

The ability to search 18,500 EEG referral forms has led to the first two studies undertaken using the Australian EEG Database. Both pilot studies have been conducted by a pediatric neurologist from John Hunter Hospital (RLLS).

STUDY 1 - EEG FINDINGS IN CHILDREN WITH DEVELOPMENTAL LANGUAGE DISORDER REFERRED TO THE JOHN HUNTER HOSPITAL OVER 11 YEARS, R. L. L. S., W. H., M. H., J. A. P. R. Aims

This study sought to examine the incidence of EEG abnormalities in children referred for investigation of language delays who did not have clinical seizures. By measuring local incidence we were also attempting to assess the potential viability of a planned prospective study.

Subjects and Methods

A retrospective search was made of the 18,500 records of the John Hunter Hospital EEG Database (JHED) for the years 1991-2001 inclusive. We searched the "history" field for EEGs of children in the age range 2 to 10 years who were referred for investigation of Developmental Language Disorder. Inclusion criteria were normal birth and early development; normal cognition and neurological examination; no medication except for sedation at the time of study. Exclusion criteria were epilepsy, cognitive disability and language regression with autism or autistic features.

Request forms for eligible patients were examined in order to make sure the patient fitted the criteria. The EEG report was reviewed and the abnormal records — epileptiform and non-epileptiform — selected. Subsequent analysis identified the type and lateralization of such abnormalities. This included an analysis for recognized EEG "syndrome" patterns. Each EEG request and all abnormal EEG digital data were reviewed by the same pediatric neurologist (RLLS).

Results

We found 166 eligible records with EEG abnormalities occurring in 25 (15%). Focal abnormalities occurred most often with neither hemisphere predominating. Of the 25 records demonstrating abnormality, 6 (24%) were awake recordings. Two records showed non-epileptiform abnormalities; 9 showed the characteristic pattern of centrotemporal spikes; 3 showed generalized discharges and the remainder a mix of focal epileptiform abnormalities (Figure 5).

Discussion

Epileptiform abnormalities were present in 23 of 166 EEG recordings of children referred for investigation of Developmental Language Disorder (DLD) who did not have clinical seizures. Historical controls suggest a figure for serendipitous EEG abnormalities in 2-4% of normal children. This represents a threefold increase over estimated background prevalence in our population of children with DLD. However, our review of other studies on EEG

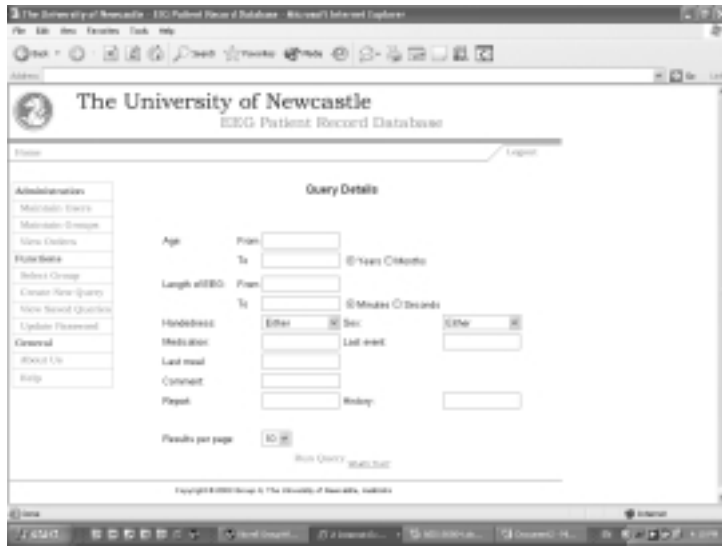


Figure 1. Current online search tool for constructing datasets.

Figure 2. EEG viewer, showing marked epochs.

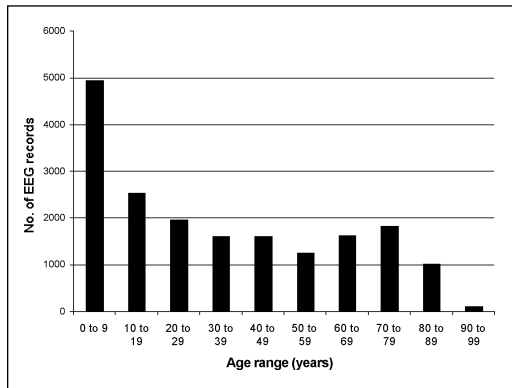
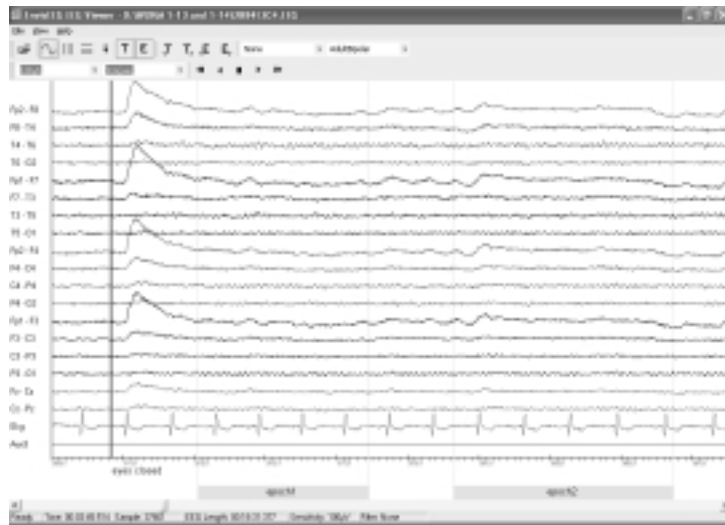


Figure 3. Age of patients at time of EEG recording.

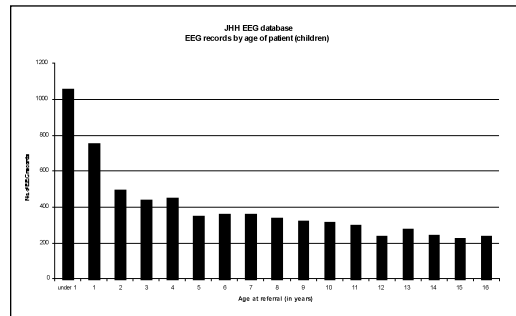


Figure 4. Age of children at time of EEG recording.

EEG recordings by term contained in referral	
Search term	Number of EEGs
"Grand mal"/GTC seizures	859
CVA	828
Psychosis	524
Migraine	298
Autism/Asperger's	141
ADHD	98
Birth asphyxia	80

and language problems in children revealed prevalence figures for epileptiform abnormalities between 20 and 100%. Our study on 166 children without a history of clinical seizures shows that only 15% demonstrated EEG abnormalities. This incidence is so small that it partly tempers the hope that epilepsy medications may improve outcome in speech and language disorders.

The EEG database was a unique research tool because we were able to search for very specific inclusion criteria from a pool of approximately 3,500 EEG records of children aged 2-10 years. These EEGs were already recorded, and captured referrals made to a regional teaching hospital over an 11-year period. It would take many years of recruiting all presentations to a general hospital to capture 166 referrals for Developmental Language Delay in otherwise normal children.

STUDY 2 – QUANTITATIVE EEG ANALYSIS OF THE MATURATIONAL CHANGES ASSOCIATED WITH CHILDHOOD ABSENCE EPILEPSY

R. L. L. S., W. H., M. H., O. A. R., R. G., J. A. P. R.

Aims

This study aimed to examine the background EEG activity in children with absence epilepsy, a condition whose presentation has strong developmental links. At least 1,083 children aged between 4 and 16 years had been referred to JHCH for the investigation of absence epilepsy. EEG hallmarks of absence seizure activity are widely accepted, and there is recognition that the bulk of interictal EEG in this group is normal to the naked eye. This multidisciplinary study aimed to use sophisticated mathematical analyses to examine the background EEG of those patients demonstrating absence seizure activity, and compare it with children without absence epilepsy. We hoped to provide insights into the fundamental mechanisms of one developmentally linked epilepsy and explore the application of mathematical tools to EEG interpretation.

Subjects and Methods

Cases for study were selected by searching in the "history" field of the JHED for children referred for the investigation of absence epilepsy. Inclusion criteria were a history of normal cognition, with absence seizures only, and free of anticonvulsant, sedation and other medication.

EEG inclusion criteria were normal EEG background to standard clinical perusal, and 3-3.5Hz spike-and-wave ictal discharge. The eligible cases were further restricted to right-handed females, aged between 6 and 8 years. The patient group of 5 subjects had a mean age of 83 months, and the control group (same inclusion criteria as patients, but with a normal EEG) of 14 subjects had a mean age of 81 months.

All EEGs were viewed and marked (using the database's EEG viewing tool) by a pediatric neurologist (RLLS). A mixture of ictal (Figure 6) and nonictal epochs were then exported as ASCII files and further analyzed using mathematical characterizations of Normalized Total Wavelet Entropy (NTWS)¹ relative to controls. This calculation can be used to define the degree of chaos in a system, with higher levels of entropy indicating a more chaotic system. Results were subjected to further statistical analyses of significance.

Results

Entropy values were calculated for patients versus controls. For all channels combined, patients with absence epilepsy showed (statistically significant) lower entropy values than controls. It is interesting that the size of the difference in entropy values was not uniform, with certain EEG electrodes consistently showing greater differences than others.

Discussion

The EEG features of absence epilepsy assumes that a 3-3.5 Hz generalized spike-and-wave occurs against a predominantly normal background EEG. A normal background to visual inspection is also seen in other generalized epilepsies. Our analysis allowed for a more detailed examination of the EEG signal than is possible with the human eye. Although the background epochs marked were indeed "normal" to standard visual inspection, the NTWS calculation demonstrates that the interictal activity in absence epilepsy patients does differ from controls.

The possibility of identifying an entropy-related digital signature for absence or other less distinct epilepsies may enable enhanced capture of those patients who may experience seizures in the case where a seizure event is not recorded on first EEG screening.

COMMENT – CLINICAL AUDIT OF EEG INVESTIGATION OF EARLY PSYCHOSIS,

D. Williams, W. Hyslop

Aims

The purpose of the study was to identify EEG requests made between 1991 and 2001 for screening purposes in early psychosis.

Subjects

The database was searched for patients aged 16-25 years where psychotic symptoms were noted in the history (referral) field. Exclusion criteria were a confirmed history of clinical seizures and acute physical illness or injury.

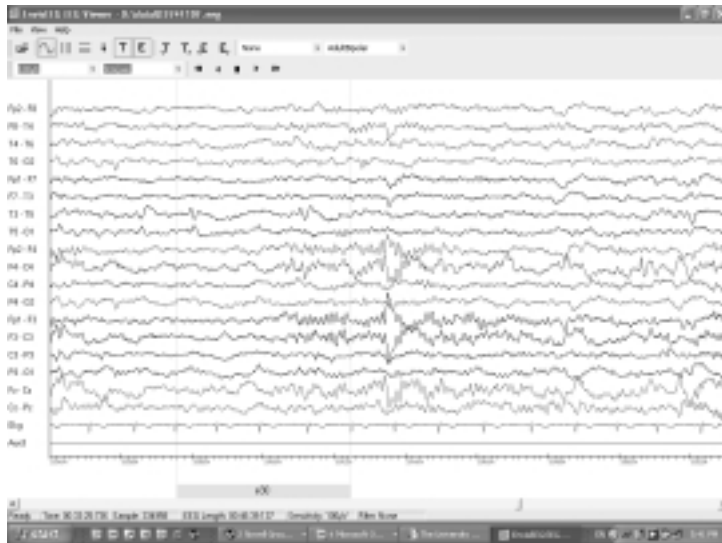
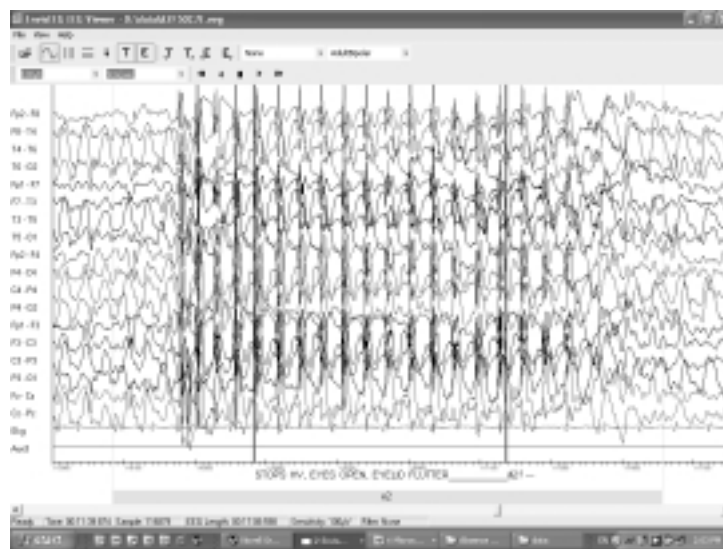


Figure 5.
EEG of 9-year-old right-handed female showing epileptogenic activity.

Figure 6.
EEG of 7-year-old right-handed female showing absence seizure.



Results

We found 132 eligible records. The mean age of patients was 20 years. The majority of patients were males (73%). The majority of EEGs (81%) were reported as normal. For 25 records, nonspecific abnormalities were reported, and a repeat EEG was only suggested in 4 of the 132 cases.

Conclusions

It is unlikely that a patient presenting with psychotic symptoms in the absence of neurological signs will be diagnosed with a neurological condition solely on the basis of the EEG. We need to consider whether routine numbers of screening EEGs is an effective way to prevent psychiatric misdiagnosis.

SCOPE OF THE AED

The resources of the AED meant that a very large number of referrals could be considered for inclusion in the language and absence studies described above. This meant that a very well defined patient group could be created. It would have taken a researcher at John Hunter Hospital 11 years to recruit these patients if he or she had waited to screen all incoming referrals.

Other examples of studies that could be conducted using the AED include investigations of neonatal seizures (for example, sequential EEG change in birth asphyxiated babies), and infantile spasms (seasonal incidence). In general, the advantage of the AED is the large number of records collected over a long period of time. This allows for

the capture of a relatively large number of cases for rare conditions, and also for the longitudinal study of selected cases. A large database such as the AED enables the use of highly specific inclusion/exclusion criteria from the patient data when choosing records to both test and formulate hypotheses. It may be that the demographic data contained in the database is as valuable as the EEG records themselves. The breadth and size of the AED also makes it an ideal source for the production of prototypical records for use in training and self-directed learning.

Furthermore, the EEG viewer software developed for the AED allows for the viewing, marking and export of any and all epochs from the 18,500 records for further analysis. This is particularly useful for researchers in the fields of physics, electrical engineering and software engineering who need access to a wide range of EEG records to test their work.

The Launch of the Australian EEG Database

The Australian EEG Database is administered by a Board of Management, comprising representatives from the John Hunter Hospital and the University of Newcastle. The establishment and launch of the Australian EEG Database was approved by the Human Research Ethics Committees of the University of Newcastle, and the Hunter Area Health Service, NSW.

Protocols and Procedures

Researchers and clinicians are asked to apply to the Board for release of data, with an application that includes the research/teaching proposal, and details of the datasets required. The prospective researcher will have to agree to conditions of use of the database, which will address issues of copyright, acknowledgment of the database in publications, and use and security of records.

If the application for release of data is approved, the researcher will be given access to a subset of the database

as relevant to the research needs, including the text-based data (with online search tools to enable the researcher to refine the dataset and communicate with others), the full EEG recording, and the viewing software to allow for marking and export of the EEG epochs of interest.

Costs

A small fee will be set for access to the database resources, based on the number of records requested and the time taken for the database curator to prepare the requested datasets. The Australian EEG database aims to operate on a cost-recovery, non-profit basis.

Contacts

The website for the Australian EEG Database is at <http://eeg.newcastle.edu.au/inquiry/>. This site is currently under construction and will be accessible by mid 2005. At this site researchers and clinicians will be able to enter their own search criteria from multiple fields to fit the inclusion/exclusion criteria for datasets of interest. The software will support arbitrarily complex Boolean searches of the database (or subsets of the database) allowing the researcher to specify words and/or expressions to be included or excluded by the search. Thus, for example, the condition "migraine" could be differentiated from "complaints of migraine" by using a filter for "migraine" AND NOT ("complain" NEAR "migraine").

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