65th ICASM Annual Scientific Meeting, Roma, September 11-14, 2017

IS THE EEG A RELEVANT TOOL OF SELECTION IN MILITARY AERONAUTICAL EXPERTISE ?

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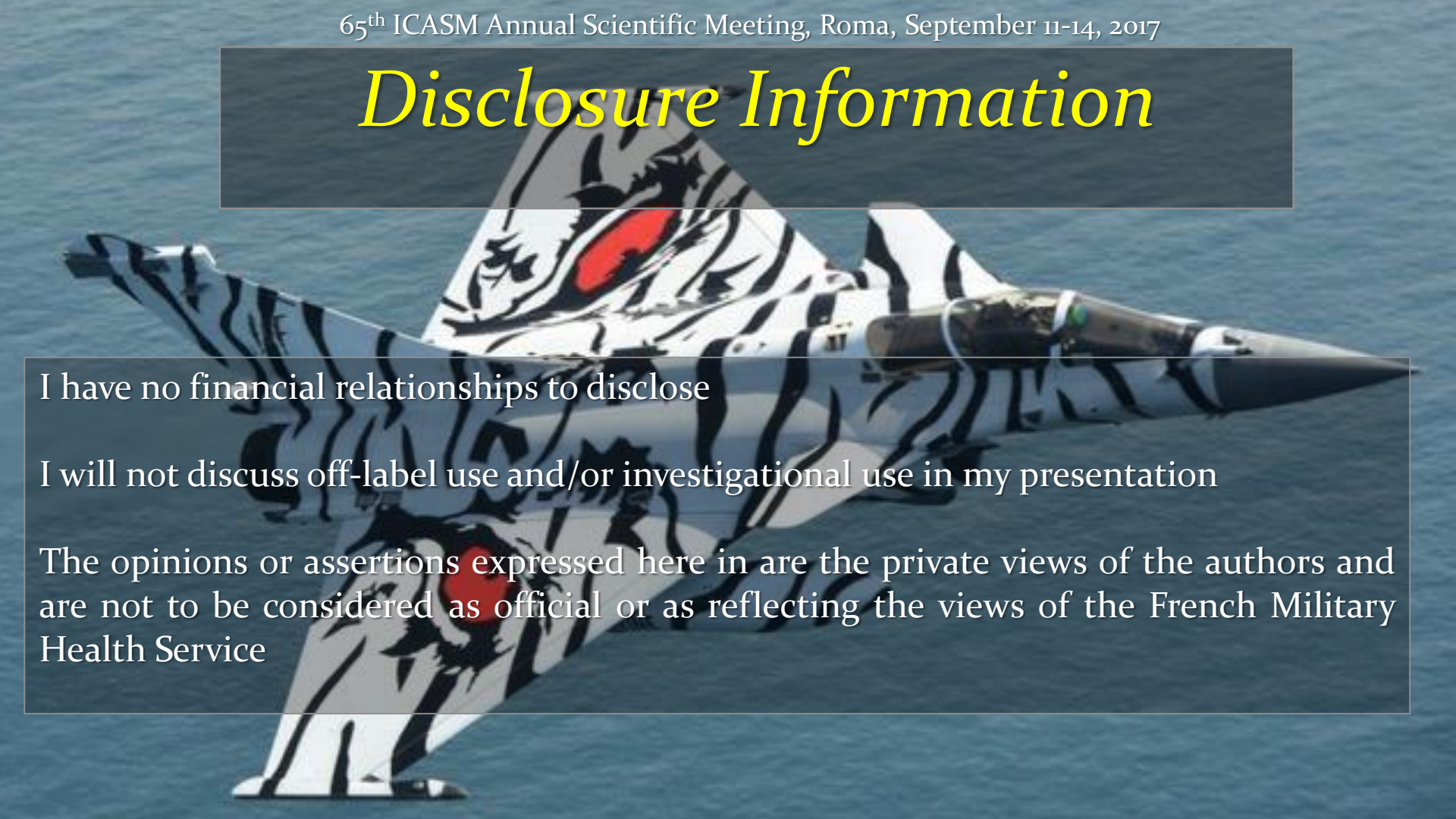
Service de santé des armées

Disclosure Information



I have no financial relationships to disclose

I will not discuss off-label use and/or investigational use in my presentation

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"... good medicine does not consist in the indiscriminate application of laboratory examinations to a patient, but rather in having so clear a comprehension of the probabilities and possibilities of a case as to know what tests may be expected to give information of value."

Francis W. Peabody, 1922

Does EEG support valuable informations as a screening tool ?

High level of medical selection

Disease's low prevalences

Low positive predictive value
of screening test

Questionning of
the utility of the test
- *Practices/Policies change*
- *Stopped use*

?

From physiology to aeromedical concerns

THE HUMAN ELECTROENCEPHALOGRAM AND ITS CLINICAL SIGNIFICANCE

BY J. E. GOODWIN AND G. E. HALL

Department of Medical Research, Banting Institute, University of Toronto

	Variations in frequency	*Variations in amplitude*
Local cortical cooling (rabbit)	decrease	decrease
Increasing body temperature (human)	increase	(increase)
Cortical anæmia (rabbit)	decrease	decrease
Hyperventilation (human)	decrease	increase
Breathing nitrogen (human)		
Rebreathing asphyxia (human)		
Breathing oxygen (human)	no effect	no effect
Inadequate oxygen (human)	decrease	

MEDICAL ASPECTS OF AIRCREW SELECTION*

BY WING COMMANDER F. A. L. MATHEWSON

R.C.A.F. Medical Service, Ottawa

« There is no place in the aircrew for the epileptic »

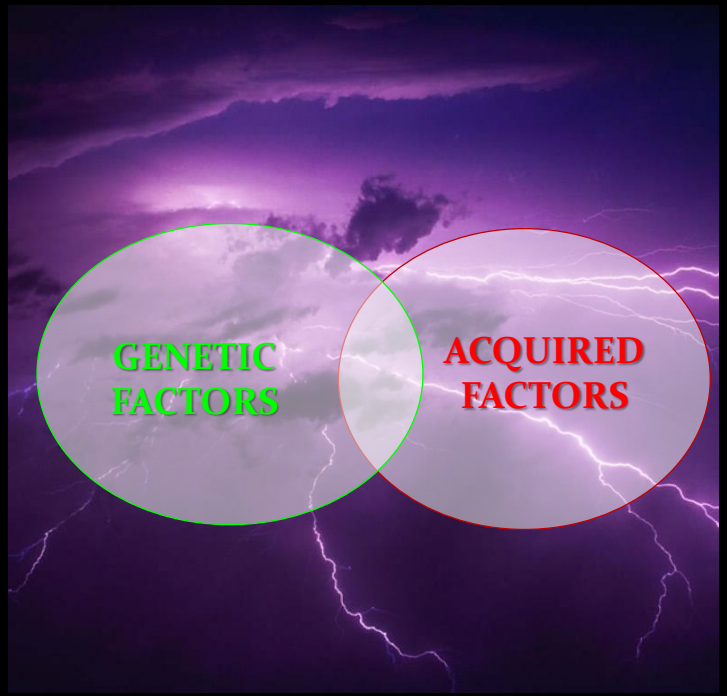
Epilepsy

- **Prevalence** : **0.3-0.8%** (by age group) *Cowan LD and al. Epilepsia (1989)*
  Hendriksen IJM, Elderson A. Aviat Space Environ Med (2001)

- **Incidence** : 0.05% per year *Hauser, Mayo clinic Proc (1996)*

  risk of 3.5% during life *Shorvon SD, Lancet (1990)*

Epilepsy



FUNCTIONAL
- Metabolic
- Drugs
- Toxic

LESIONAL
- Brain injury
- Stroke
- Tumor
- Infection
- Scar tissue

« OPERATIONAL » FACTORS

- Lack of sleep
- Exhaustion (workload)
- Day-night-rhythms
- Jet Lag
- Hyperventilation
- Photic stimulation
- Hypoxia
- Stress (air strikes)
- ...

EEG and Epilepsy

- **Epileptiform abnormalities in « healthy subjects »**

  0.5% (from 13.000)

  Gregory and al. Electroenceph Clin Neurophysiol (1993)

  2.4% (from 5.000)

  Trojaborg and al. Clin Electroenceph (1992)

- **A performing test ?**

  Sensitivity < 55%

  (*92% after a 4th record, Salinsky et al, 1987*)

  Specificity ≈ 97%

Disponible en ligne sur ScienceDirect www.sciencedirect.com
Elsevier Masson France EM|consulte www.em-consulte.com/en
ELSEVIER MASSON

RECOMMANDATIONS/GUIDELINES

Recommandations françaises sur l'électroencéphalogramme☆

French Guidelines on electroencephalogram

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French guidelines, Clinical Neurophysiology (2015)

A great deal of discussions...






366 EPILEPSIA VOL. 1 (1959/60)

Correlation of Electroencephalographic Findings with Crash Rate of Military Jet Pilots

M. LENNOX-BUCHTHAL, F. BUCHTHAL AND P. ROSENFALCK

Institute of Neurophysiology, University of Copenhagen, and the Aero Medical Institute, Copenhagen (Denmark)


?




AGAINST

INCIDENCE OF IN-FLIGHT EPILEPSY

- Rate of accident < acceptable minimum risk *(1% rule)*
- 1 in-flight seizure / 4 years (10,000 pilots)

MILITARY SERIES INCONCLUSIVE

- No/few follow up
- No recent studies
- Lack of statistical power

NOT DEMONSTRATED BENEFIT

- Rare in-flight seizures
- Registered event/countries

ANALYTIC CHALLENGES

- Pathological vs physiological paroxystic activities

UNCLEAR MEDICAL STATUS

- EEG's loss of meaning

LOW PROGNOSTIC VALUE

- PPV : 7-8%
- Seizure's low prevalence among applicants

Zivkin BG, Epilepsy and Behavior (2005)

Mitchell SJ, Schenk CP, Occup Med (2003)

Clark JB, Riley TL, Aviat Space Environ Med (2001)

Everett WD, Akhavi MS, Aviat Space Environ Med (1982)

FOR

Hendriksen IJM, Elderson A. Aviat Space Environ Med (2001)

Glaser H, Freund W. AGARD-CP-553 (1994)

Murdoch BD. Percept Mot Skills (1993)

Kasteleijn-Nolst Trenité DGA and al. Electroenceph Clin Neurophysiol (1987)

King WH, Liske E. Aerospace Med (1974)

Rayman RB, Aerospace Med (1971)

Lennox-Buchtal M and al. Epilepsia (1959)

FLIGHT SAFETY

- Risk of accident / In-flight incapacitation
- Epilepsy : 1st cause of non-physiological LOC

MILITARY AVIATION CONCERNS

- Operational factors lowering epileptic threshold

EXTRAPOLATION MODEL

- Probability of epileptic seizure x 12 in case of « positive » EEG

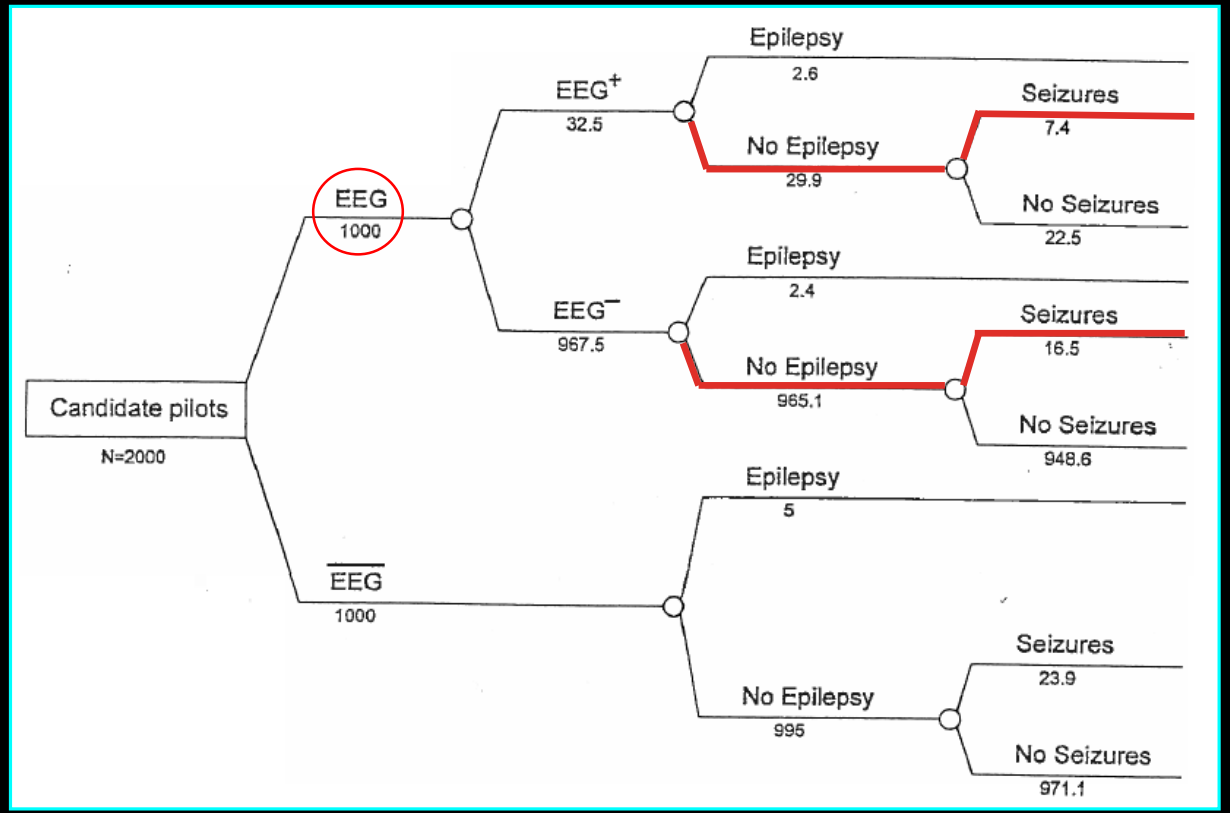
INTERCRITICAL FINDINGS

- EEG as a « gold standart »

TRANSIENT COGNITIVE IMPAIRMENT

- « Asymptomatic » discharges
- Driver's behavior

Hendriksen IJM, Elderson A. Aviat Space Environ Med (2001)



25%

x 12

2%

French Military Aeronautics Standards

- MI 800 of 2008/02/20th

« doubtful or pathological activities are leading to unfitness » :

- Definitely :

- « Significant paroxysmal phenomenom (provoked or not by activation tests) »
- « Focal slow activities or paroxystic discharges after brain injury »

- Temporary :

- « Moderate and transient anomalies after a NSC agression »
- « Fonctional anomalies provoked by an identified and resolutive context »

A 2nd expert opinion possible at request of the applicant (after 2nd rest EEG, sleep deprivation EEG, cerebral MRI…)

BULLETIN OFFICIEL DES ARMEES

Edition Chronologique

PARTIE PERMANENTE
Etat-Major des Armées (EMA)

INSTRUCTION N° 800/DEF/DCSSA/AST/AME
relative à l'aptitude médicale aux emplois du personnel navigant des forces armées.

Du 20 février 2008

Retrospective studies

2 prevalence studies

- N° 1 : AeMC Percy Military Hospital (Clamart) : 9 years (2007 - 2015)
- N°2 : AeMC Sainte-Anne Military Hospital (Toulon) : 1 year (2016)

1 impact study

- N°3 : Multicentric survey (piloted by AeMC Percy) : 9 years (2007 – 2015)

Prevalence studies (N°1 and 2)

1) Materials and methods

- ***Type*** :

- **2 retrospective**, **descriptive**, **transverse** and **monocentric** studies

- Based on EEG analysis performed

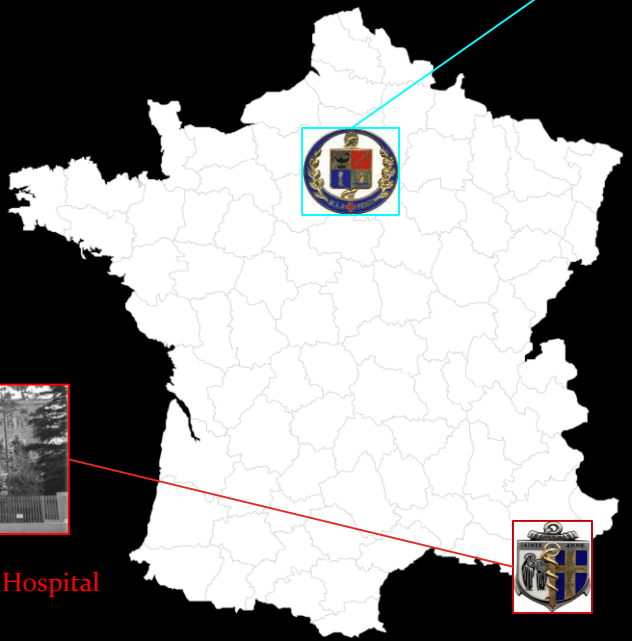
- ***Population*** :

- **Military applicants** for aircrew and air traffic air controllers

- ***Purpose*** :

- To observe and classify EEG anomalies to deduct a **prevalence**

Percy Military Hospital (Clamart)



Sainte-Anne Military Hospital (Toulon)

4 061 patients included

- 3 911 (96.3%) : strictly normal
- 150 (3.7%) : abnormal or doubtful

3 413 ♂/ 648 ♀ (Sex Ratio : 5)

Average age : 22 years

Median age : 20 years

Clamart

373 patients included

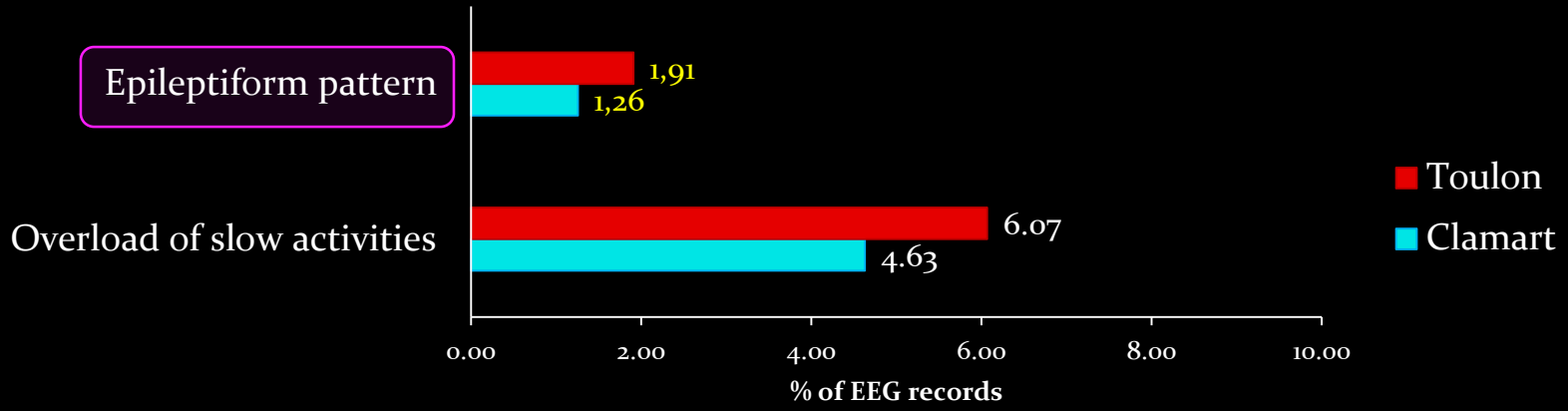
- 288 (92%) : strictly normal
- 25 (8%) : abnormal or doubtful

265 ♂/ 48 ♀ (Sex Ratio : 5.5)

Average age : 22 years

Median age : 21 years

Toulon



Prevalence studies (N°1 and 2)

2) Results

- **total anomalies revealed by activation tests**

  Clamart : 35% Toulon : 20%

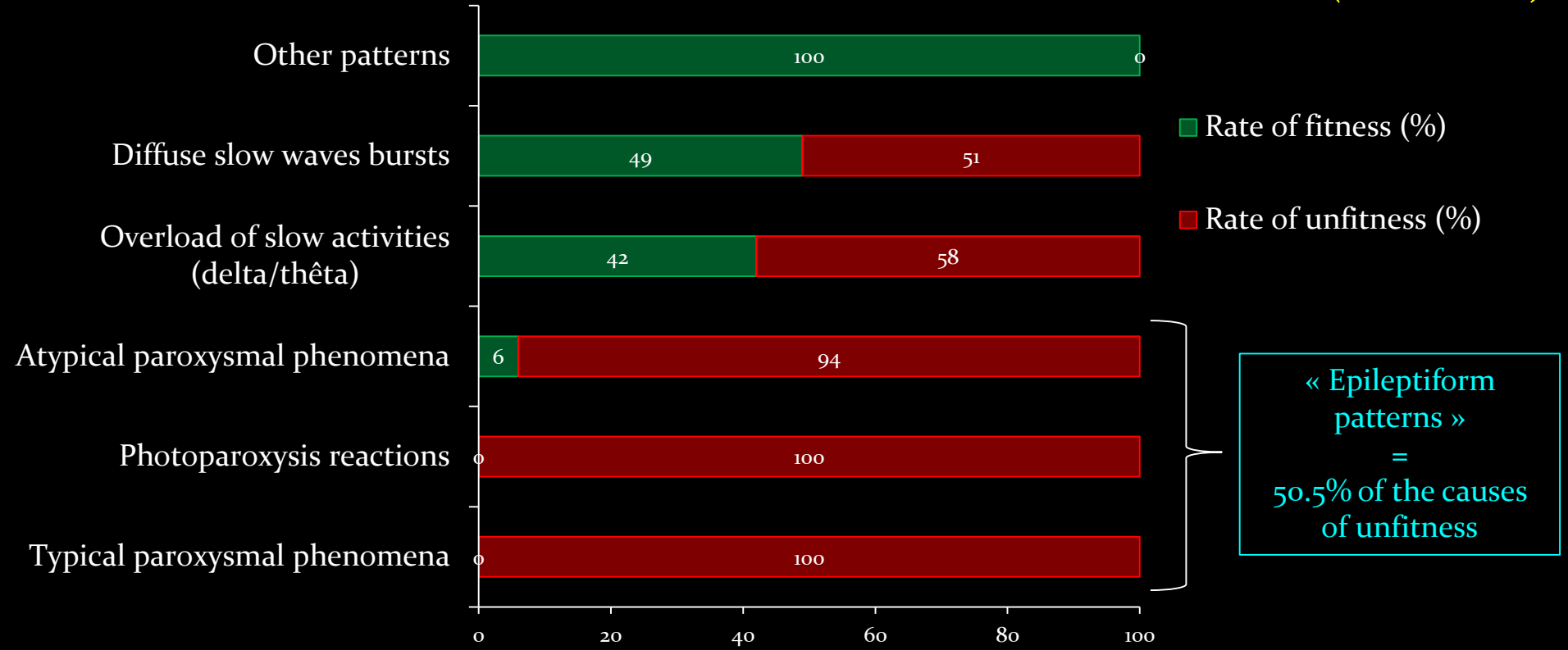
- **rest anomalies majored by hyperpnea**

  Clamart : 50% Toulon : 67%

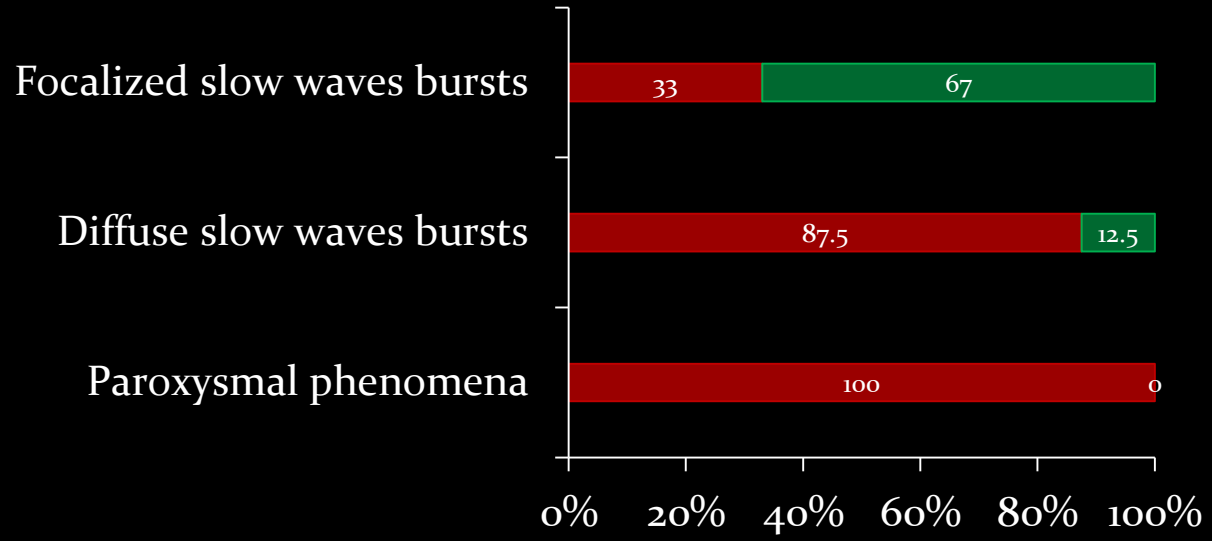
Global unfitness rate :

Clamart : 2.4 % Toulon : 6.7%

Rate of unfitness according to described anomalies (Clamart)



Rate of unfitness according to described anomalies (Toulon)



« Epileptiform patterns »
=
28.6% of the causes of unfitness

Overview…

Hendriksen IJM, Elderson A. Aviat Space Environ Med (2001)

Author (Ref.)	Date	Subjects	Abnormal EEG (%)	Epileptiform EEG (%)	Follow-up
Lachaud et al.	1971	French pilot candidates, 18-22 years	152/2700 (5,63%)	73/2700 (2,7%)	-
LeTourneau & Merren	1973	Naval aviation students, 19-29 years	38/28658 (0,13%)	21/28658 (0,07%)	1 of 31 with an abnormal EEG located had a seizure in 11 years follow-up
Oberholz	1976	German AF candidates 15-57 years	61/973 (6,3%)	13/973 (1,34%)	-
Maulsby et al.	1976	French AF pilots and other crew members	2050/10000 (20,5%)	250/10000 (2,5%)	No seizure after 4-10 years
Robin et al.	1978	USAF male aviators, 18-55 years	166/7760 (2,14%)	76/7760 (0,98%)	1 of 20 followed up had a seizure during EEG recording
Everett & Akhavi.	1982	USAF Academy cadets, 4th year	85/2947 (2,9%)	14/2947 (0,48%)	No seizures after 10-15 years
Trojaborg	1992	RDAF male applicants, 17-28 years	142/5893 (2,4%)	Mainly paroxysmal (≤ 2,4%)	(4 applicants developed a seizure during EEG recording)
Gregory et al.	1993	RAF candidates, 17-25 years	-	69/13658 (0,5%)	1 of 38 followed up had a seizure during 5-29 years follow-up
Ribeiro	1994	AF pilot applicants and other crew applicants	92/2015 (4,57%)	38/2015 (1,89%)	(1 with a normal initial EEG had a seizure during 15 years follow-up)
Ferain	**2017**	**French aircrew and air-traffic control applicants**	**150/4016 (3,7%)**	**51/4016 (1,3%)**	**1 of 44 followed up with a seizure during prophylaxy by mefloquine**
Huiban	**2017**	**French aircrew and air-traffic control applicants**	**25/313 (8%)**	**6/313 (1,9%)**	**-**

Impact study (N°3)

- ***Type*** :

- An analytical and **descriptive** study of a **longitudinal** and **multicentric cohort**.

- Population included between **2007/01 and 2016/02**.

- Use of a **questionnaire**

- ***Purpose*** :

- To draw a pronostic value of abnormal EEGs previously observed

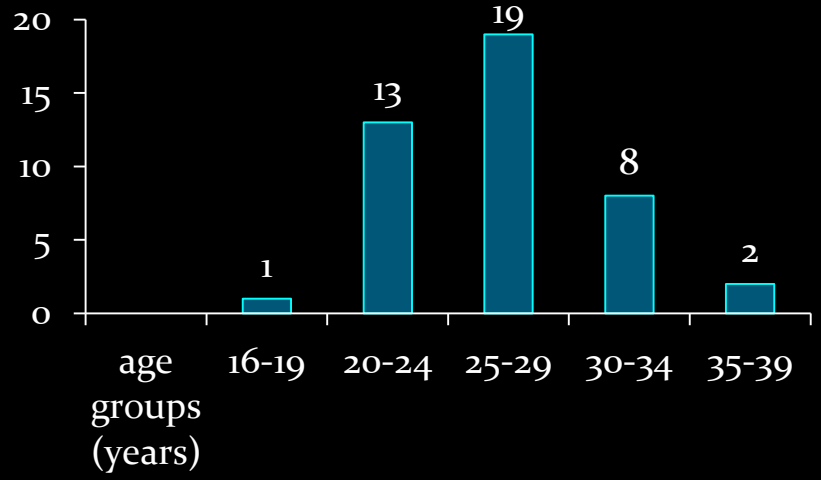
Percy Military Hospital (Clamart)

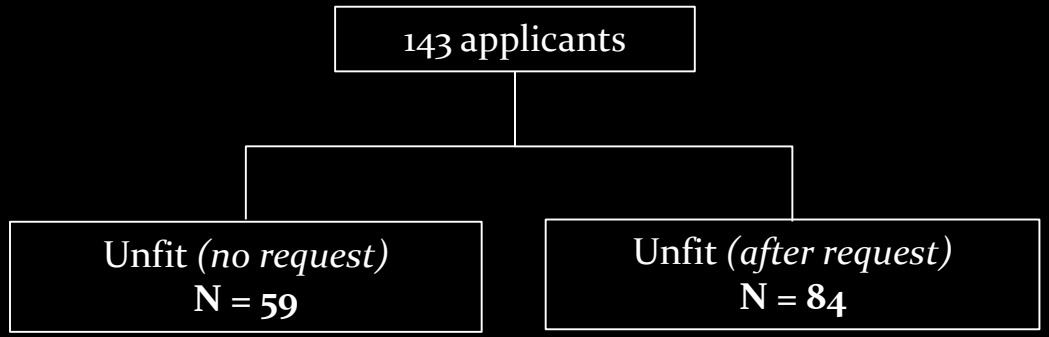
Robert Piqué Military Hospital (Bordeaux)

Sainte-Anne Military Hospital (Toulon)

Impact study (N°3)

- ***Population*** :





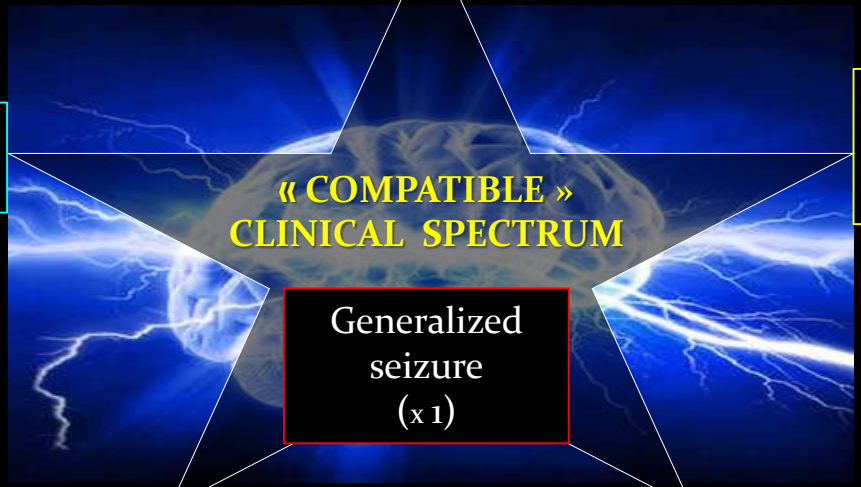
- *Participation* : **30%**
  (44 returns of filled questionnaires)

- *Average age* : **26.7 years**

- *Mean length of follow-up* : **4.8 years**

Impact study

2) Results



Convulsions
(x 2)

Loss of contact
(x 1)

Loss of consciousness
(x 1)

Generalized seizure
(x 1)

x 3 discomfort
+/- « loss of consciousness »

Sensory hallucinations
(x 1)

Abnormal motion
(x 1)

Overview…

1 of 44 followed up with a seizure during prophylaxy by mefloquin

TABLE I

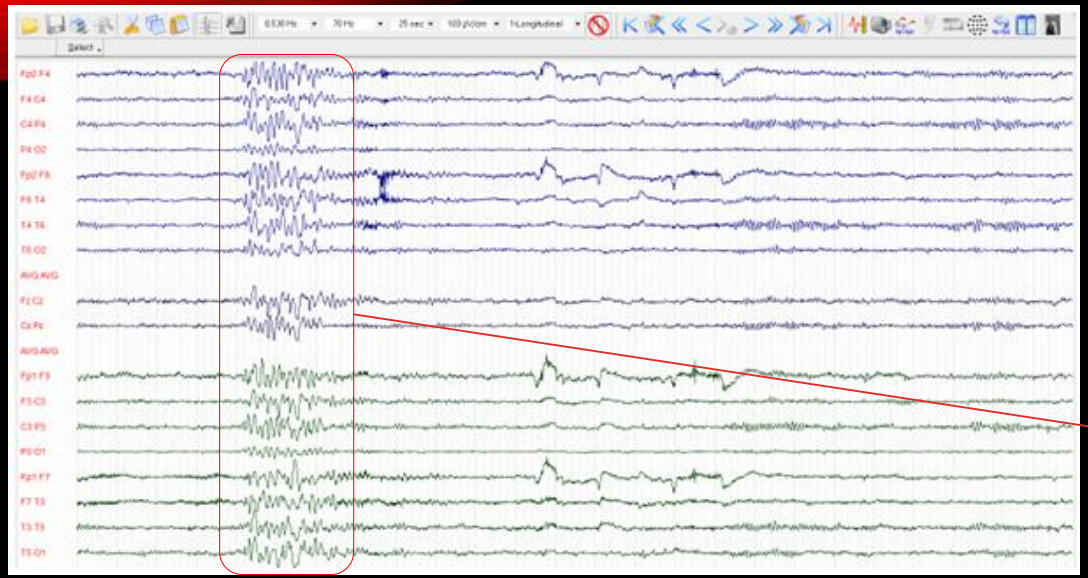
Follow-up studies.

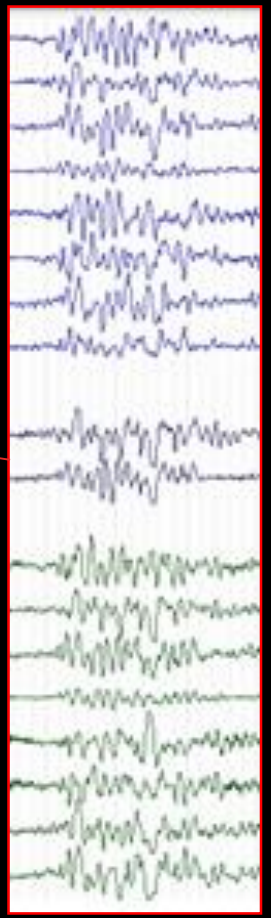
Author	Year	Population	No. followed	No. developing epilepsy
Zivin	1968	Medical	47	1
Le Tourneau	1973	U.S. Navy	31	1
King	1974	USAF	30	1
Everett	1982	USAF	14	0
Gregory	1992	RAF	38	1
Ferain	2017	French Army	44	1

204 / 5 = 2.5 %

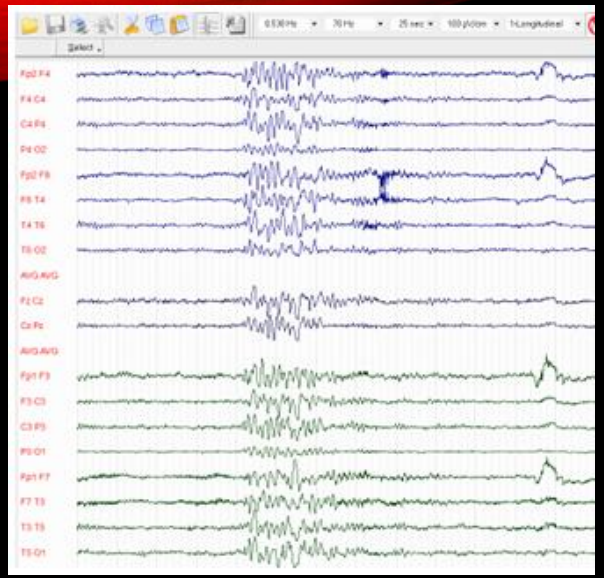
R.P. Gregory et al. Electroencephalography and clinical Neurophysiology (1993)

A relevant decision





A relevant decision



Risk of future epilepsy ?

- "Ep. Discharges"
  ≠ pathognomonic

→ Higher incidence ?
(combined data)

→ Predisposition ?

→ large control group required
(not available or impossible)

T.C.I. due to "Ep. Discharges" ?

- Effects on drivers behavior
  → flight safety ?

Cost-benefits ratio ?

- Dual purpose
- Cost of "one avoided incident"

Ways for a decision

Epileptiform pattern → ≠ Epilepsy

→ "Functional traits" *susceptible to be translated* by neurological signs / seizure in conditions of reducing threshold (operational factors)

EEG : a tool of the past ?

Supermarine « Spitfire »

Dassault Rafale

Perspectives

- **Long term monitoring EEG** : paroxysmal activity studied over extended periods (data compression algorithms / automatic detection of grapho-elements)
- **Video-EEG** : behavioral manifestations consistent with T.C.I.
- Functionnal brain mapping : **HR-EEG** and **MEG** (spatial resolution)
- A study on the **significance** of epileptiform paroxysms (simulation training)

→ creation of large and searchable **databases**

→ to establish and validate the **risks for developing epilepsy**

Velis ND, Epilepsy & Behavior (2005)


Thank you for attention