迷雾中的认知脑电？

（零参考与认知脑电）

报告人：尧德中

dyao@uestc.edu.cn

What's EEG ?

“一首流淌的歌”

EEG 是一首流淌的歌 ？

一位癫痫患者的脑电歌

- “眼睛容不得沙子”

- “耳朵能容得下“沙子”音吗？

带干扰的癫痫脑电歌

掺进了一点点“沙子”

破坏了原有的“和谐”

脑电中的“沙子”是什么？

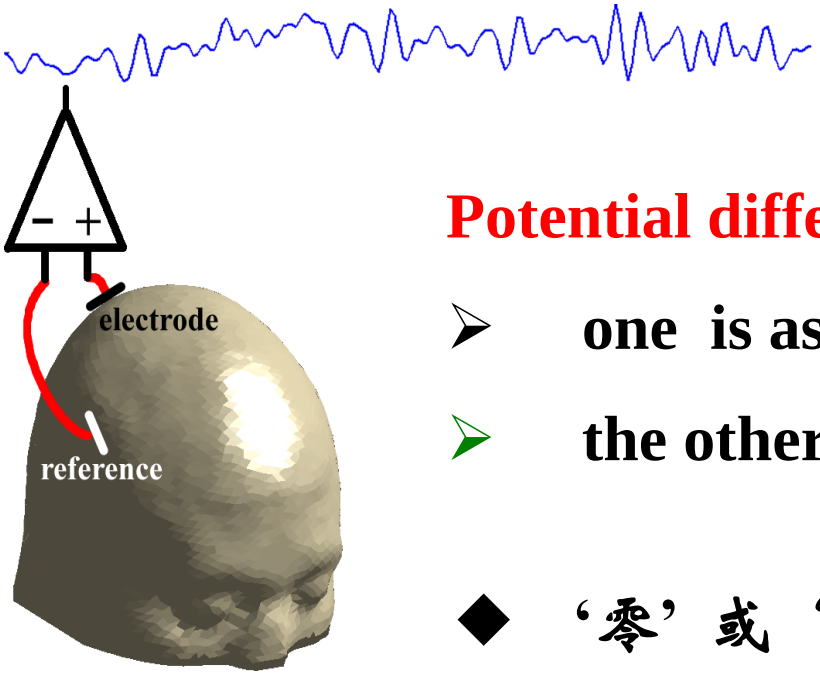
- 仪器噪音？
- 环境噪声？
- 眼动噪声？

□ 非零参考？

参考电极问题的由来？

“没有参考，何知未来”

◆EEG recordings (potential)

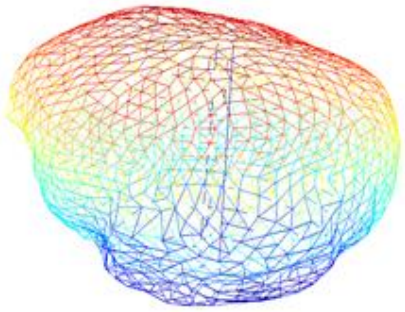


Potential difference between two points:

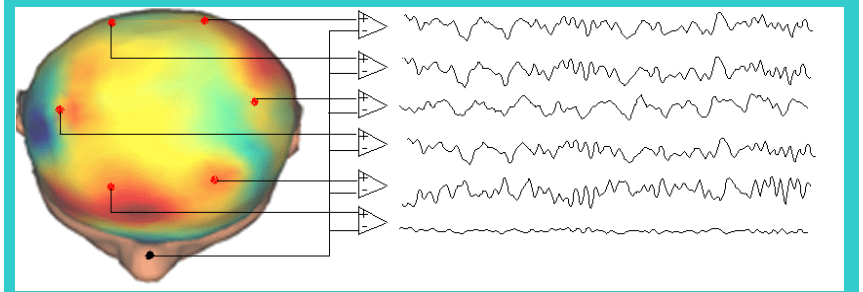
- **one is assumed as the active point**
- **the other is assumed as the reference point**

◆ ‘零’或‘恒定’电位才配作‘参考’

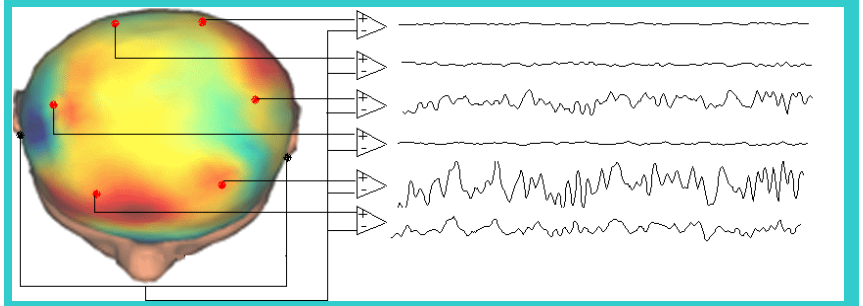
◆EEG recordings (potential)



Source in head



Nose as reference



Linked ears as reference

Curse

Dynamic EEG,

no point on scalp or body surface, where the potential is always zero

五花八门

百年努力

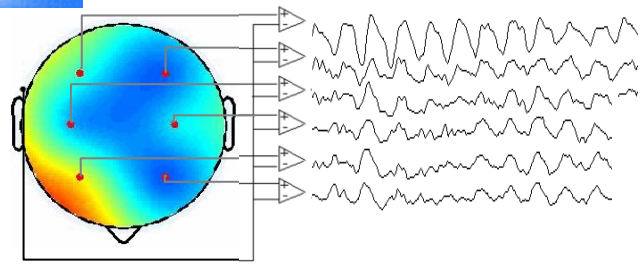
百年等待

（1929-）

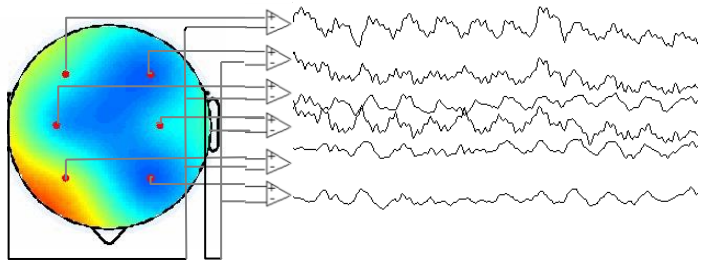
没有标准

只看权威

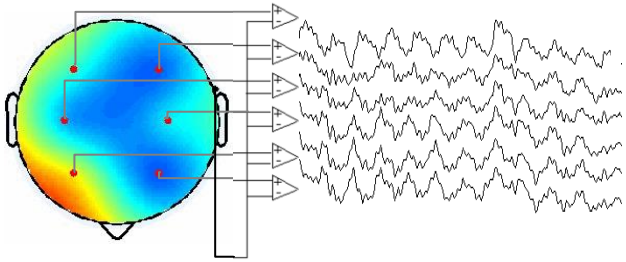
Left Ear



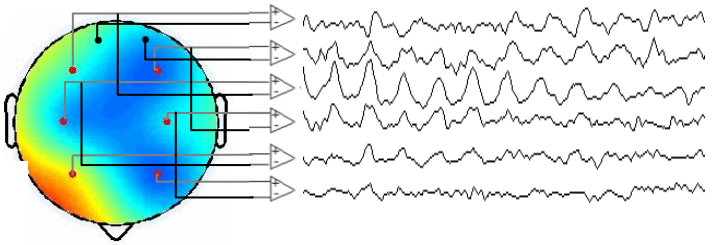
Ipsilateral Ear



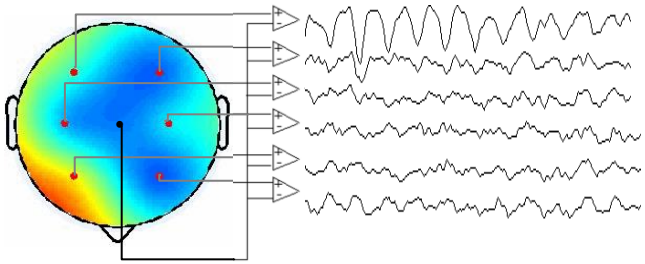
Right Ear



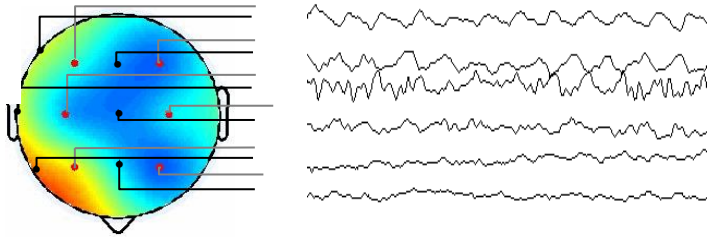
Bipolar (longitudial)



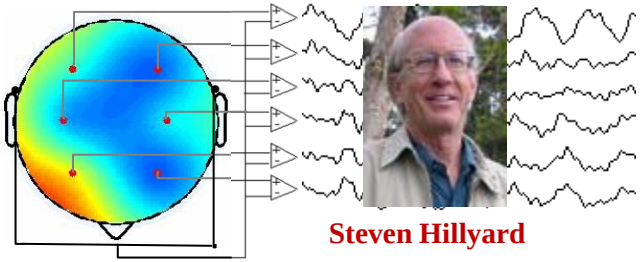
Cz



Bipolar (Transverse)

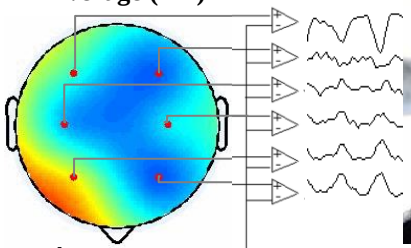


Linked Mastoids(LM)



Steven Hillyard

Average (AR)



Average

Guillaume Thierry

寻找零参考的足迹？

“一路向零”

Where is the Zero reference?

Physics of Electricity

Definition of potential

$$V \sim \frac{q}{r} \longrightarrow 0, \ when \ \ r \rightarrow \infty$$

Infinity is the physical reference zero

Where is the Zero reference?

早期的方案--实验方法

--寻找0电位点

1) To set a reference point at infinity?

Impossible!

2) To set a reference point on scalp or body surface where the potential is zero?

Impossible!

空有理想，不接“地”气

Where is the Zero reference?

近期的方案—肘域信号分析方法

--算出参考信号，然后予以减去

1) **Average** of all scalp recordings? 平均参考

（假设所有电极电位平均值是零）

2) Average of the two ears (**linked-ears**)? 连接耳参考

（假设两耳电位平均是零）

3) To recover reference signal by ICA, PCA etc?

Impossible as reference signal is quite similar to other channels

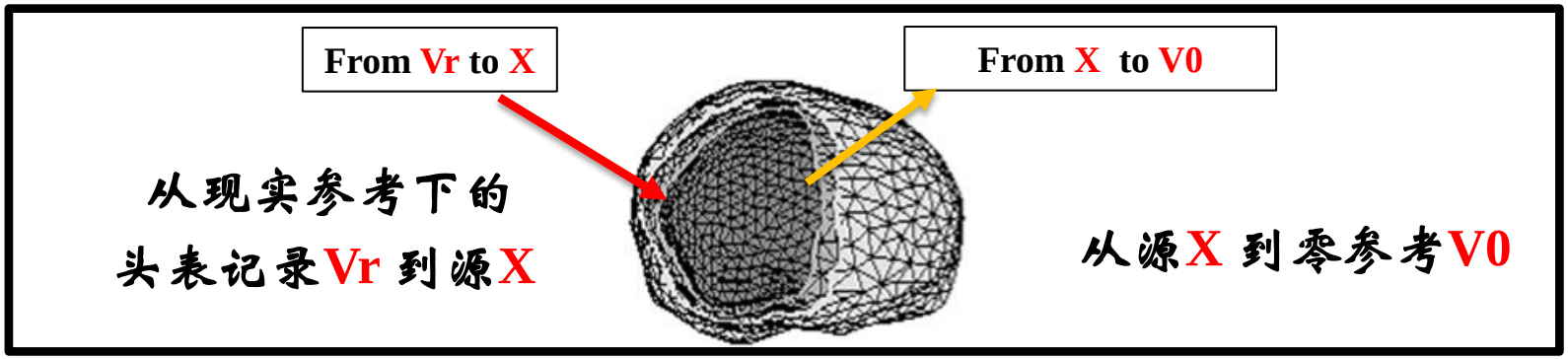
（假设参考点的电位与其他电极处的电位有明显的统计学差异）

主观假设，缺乏依据

Where is the Zero reference?

现在和未来的方案—空域信号分析方法

- **问题的物理本质**
  - 任何参考下的头表信号Vr都是颅内源X产生的
  - 重建等效源X 即可重建头表信号V0



参考电极标准化技术（REST）

（reference electrode standardization Technique）

基于问题物理本质的方法

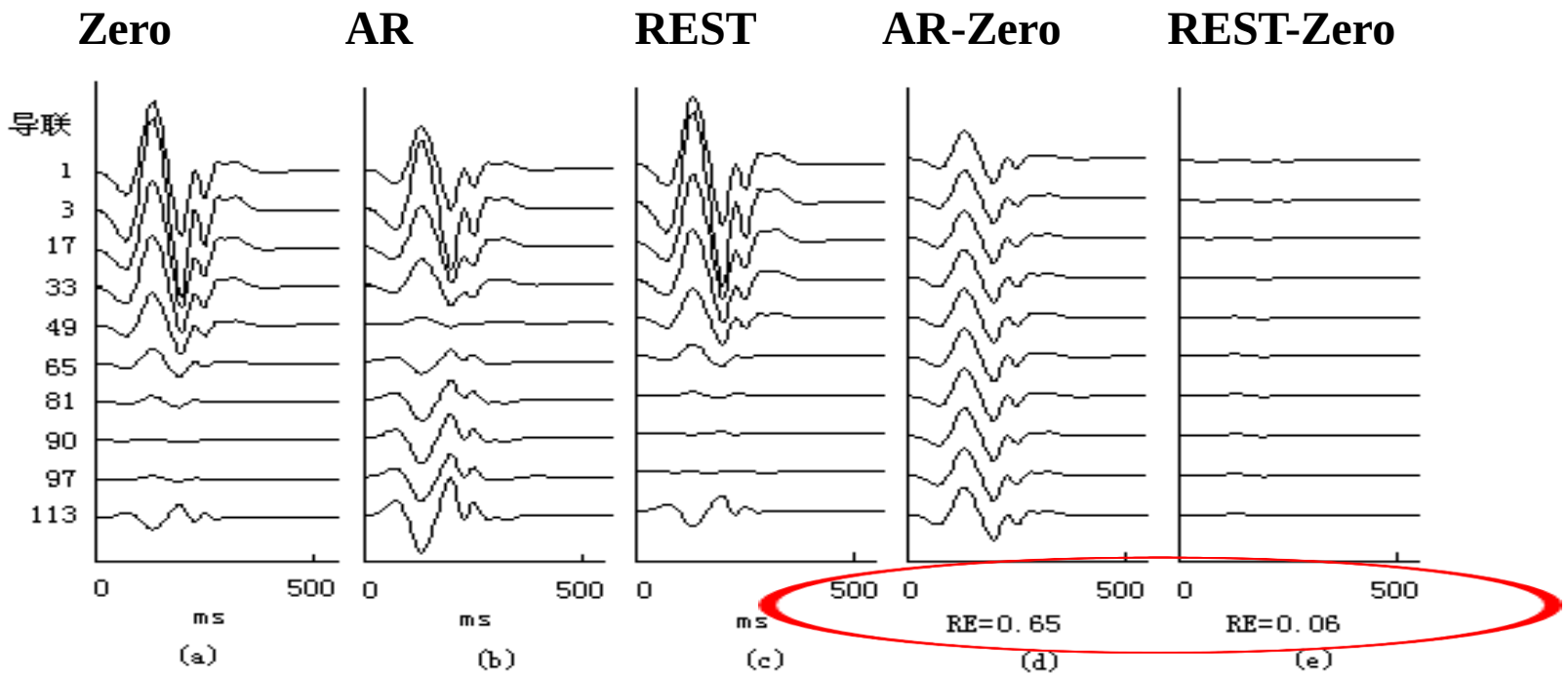
Yao etal 2001

REST(零参考)的效果？

“不比不知道”

REST 的效果

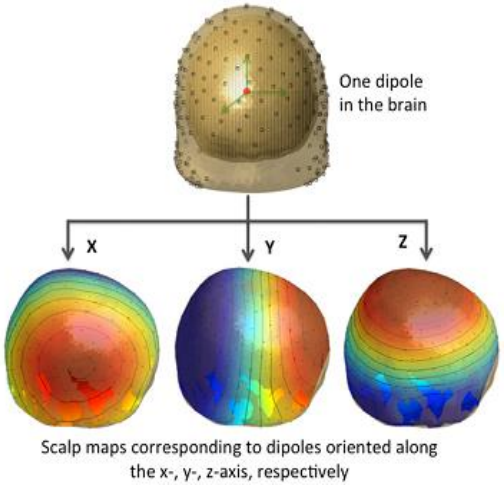
- 全脑波形的差异



Yao etal 2001

REST 的效果

各脑区的波形差异



Scalp maps corresponding to dipoles oriented along the x-, y-, z-axis, respectively

		X	*Y*	*Z*	*XYZ*
Frontal	AR	2.32% (0.75%)	7.14% (0.63%)	−5.53% (1.75%)	1.31% (0.73%)
	REST	0.48% (0.21%)	0.10% (0.08%)	−0.32% (0.21%)	0.09% (0.08%)
Central and parietal	AR	1.98% (0.56%)	−2.15% (1.26%)	−2.09% (0.71%)	−0.75% (0.53%)
	REST	0.23% (0.18%)	0.033% (0.12%)	−0.16% (0.10%)	0.03% (0.10%)
Occipital	AR	−2.92% (4.20%)	−5.50% (0.41%)	−5.13% (1.92%)	−4.52% (1.54%)
	REST	−0.18% (0.45%)	0.01% (0.07%)	0.49% (0.49%)	0.11% (0.22%)

Realistic head model, 256 channels

- **REST 的误差明显小于平均参考**
- **明确把REST列在三种最常用参考的首位（“the most commonly used EEG re-referencing techniques, such as REST, AR and LMR”）**

牛津大学 Mantini etal JNE (2015)

REST 的效果

- 对脑网络分析的影响

IOP Publishing
J. Neural Eng. 13 (2016) 036016 (21pp)
Journal of Neural Engineering
doi:10.1088/1741-2560/13/3/036016

Impact of the reference choice on scalp EEG connectivity estimation

Federico Chella[1,2], Vittorio Pizzella[1,2], Filippo Zappasodi[1,2] and Laura Marzetti[1,2]

- 误差显著小于其它参考

"demonstrated that **REST significantly reduced** the distortion of connectivity patterns when compared to AVE, Cz, and DLM references"

- 明确推荐大家使用

"we **recommend the use of** the REST reference"

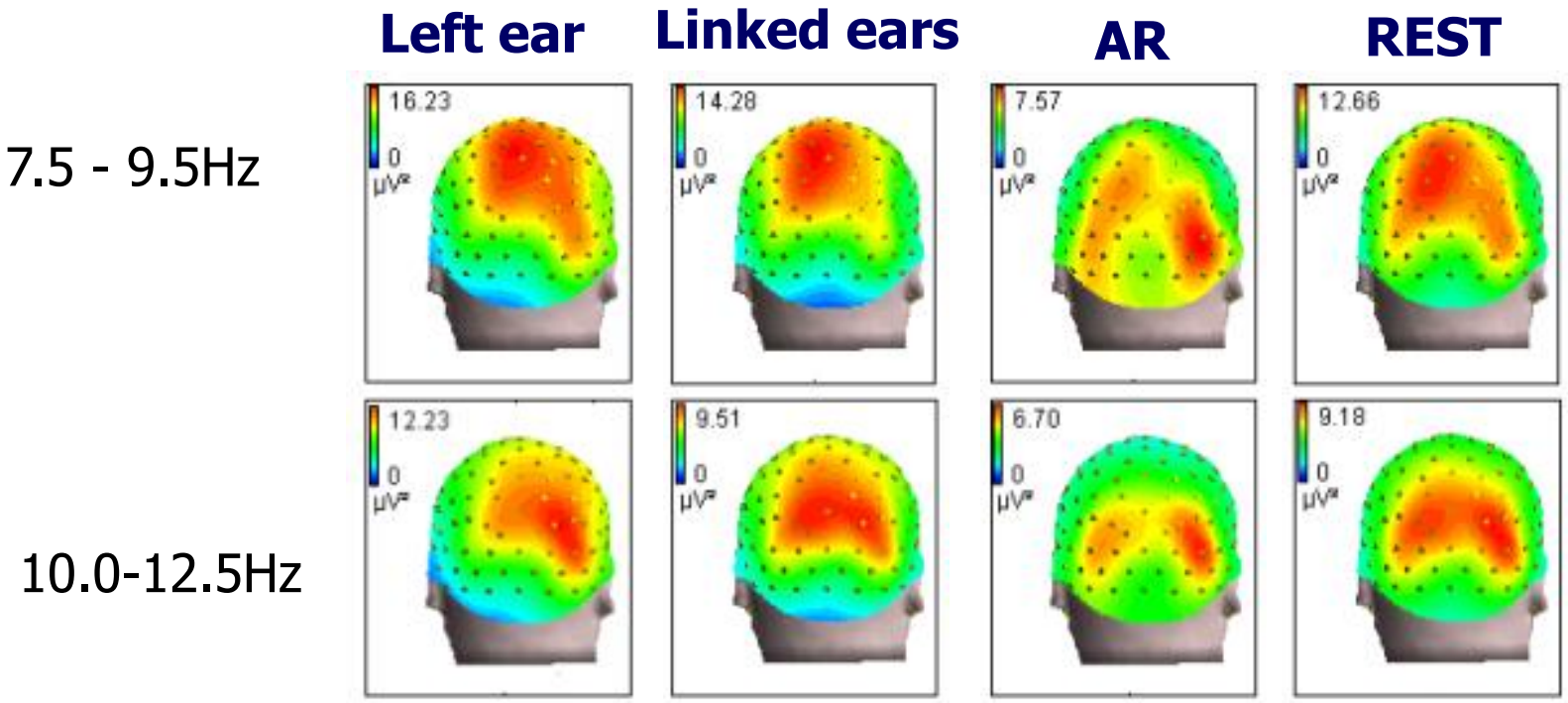
意大利 Marzetti etal. JNE, 2016

REST与自发脑电(EEG)？

EEG：the signal of “default mode”

1.Spectrum Power: Basis of qEEG

非零参考导致功率谱地形图出现系统性偏移



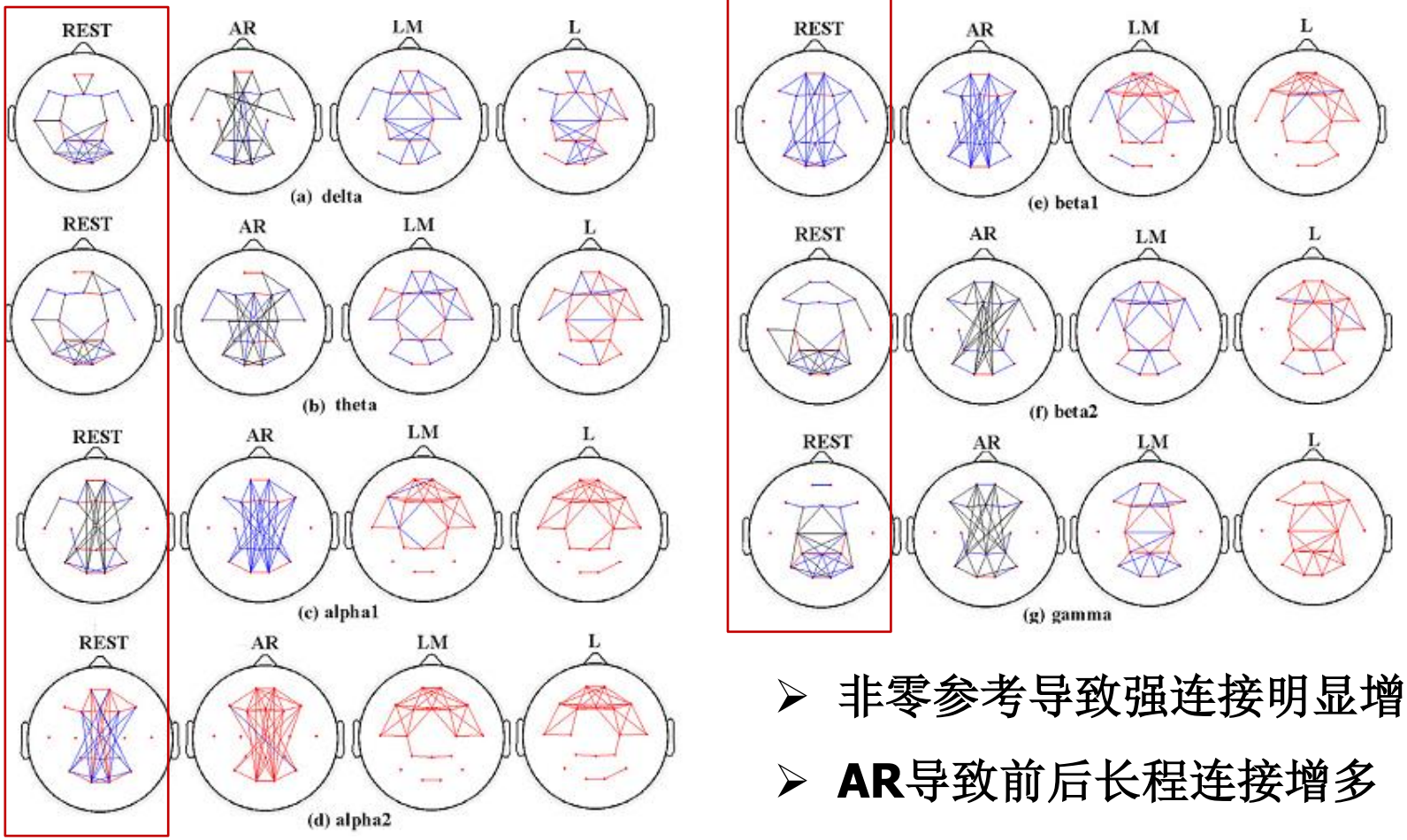
Robert Barry

当前：

- 临床定量脑电惯用连接耳
- 认知脑电惯用平均参考或连接耳

Yao, Chen etal, Physiol Meas, 2005, 26:173

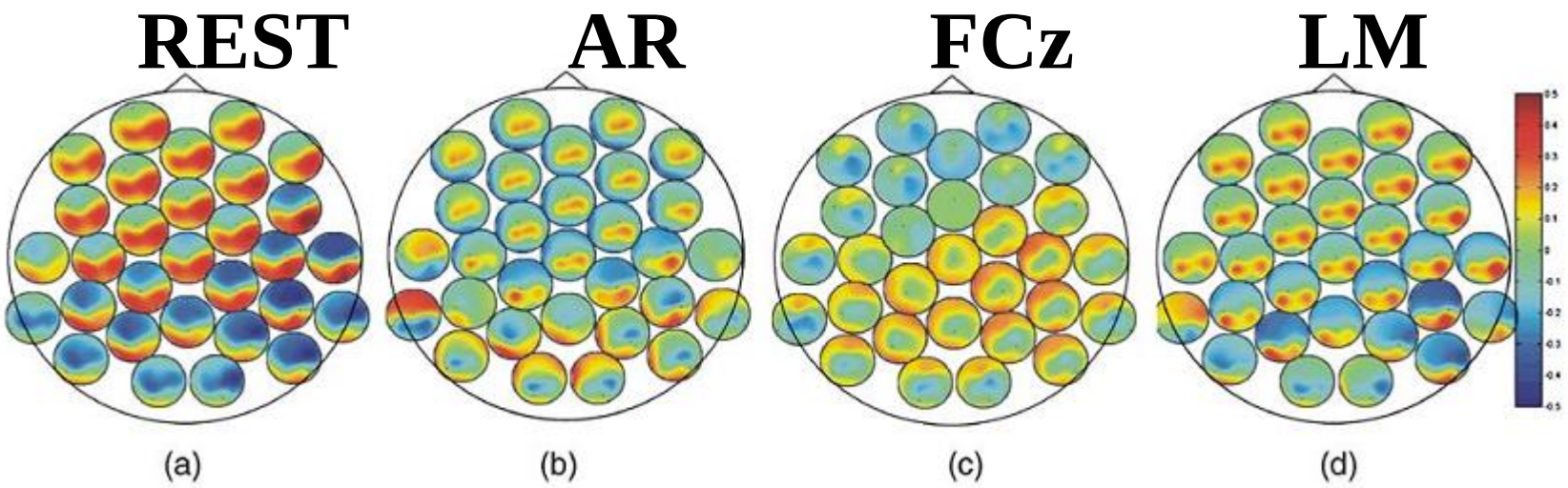
2. DMN of EEG



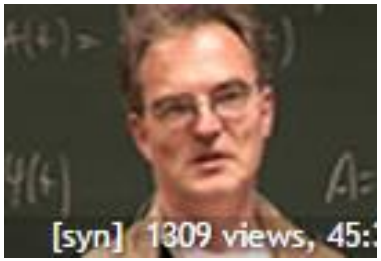
- 非零参考导致强连接明显增多（红色）
- **AR**导致前后长程连接增多
- **LM,L** 破坏了枕部的连接
- 连接性有明显的频段依赖性

Qin et al 2010 Clin Neurophysiol

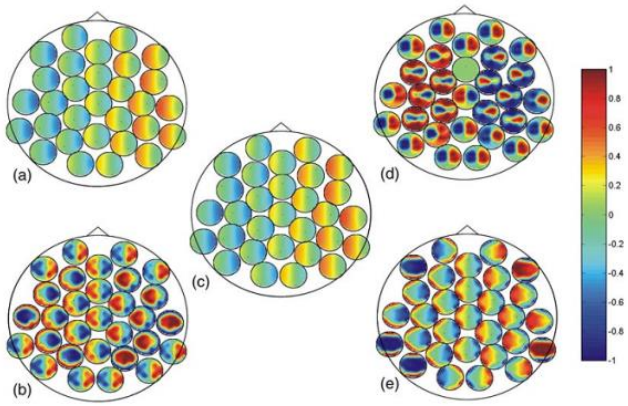
3. Imaginary part of complex coherency



- REST更好地反映了枕-顶相互作用
  其Pattern平滑、简单，更合理



Marzetti, Nolte etal NeuroImage, 2007

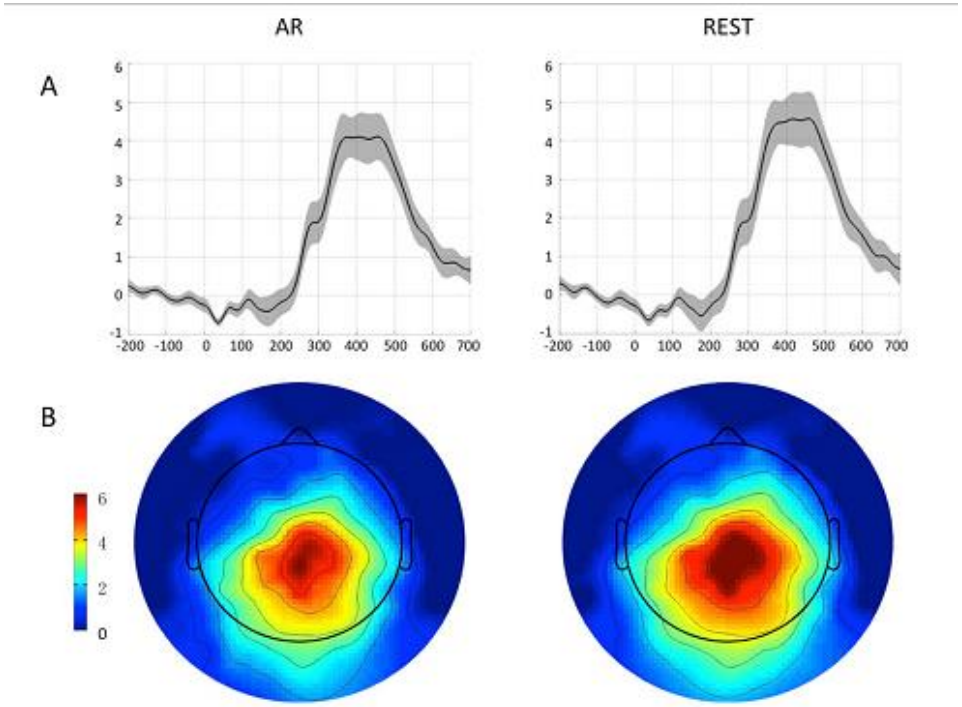


仿真发现，其它参考会引入虚假的复杂pattern

REST与诱发脑电(ERP)？

“ERP 是21世纪的反应肘”

1. P300 信号更强



“Significantly stronger P300 signals over the parietal cortex Pz using REST rather than AR **(Wilcoxon Signed Ranks Test, Z =2.896, 2-tailed p=0.004) , whereas no significant difference between noise levels from REST and AR was found(Z = 1.758, 2-tailed p =0.079)”.**

Mantini etal JNE (2015)

2. 视听整合中的注意效应

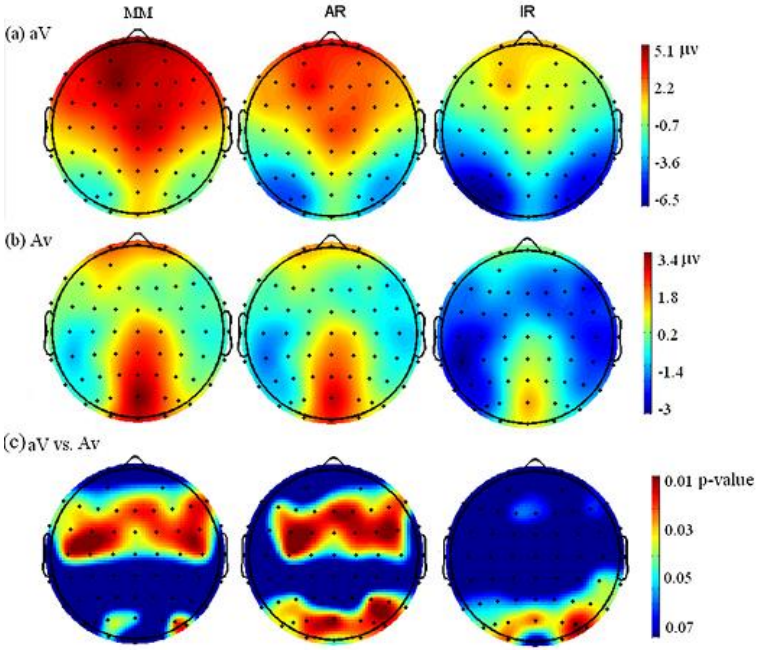
视听同步刺激

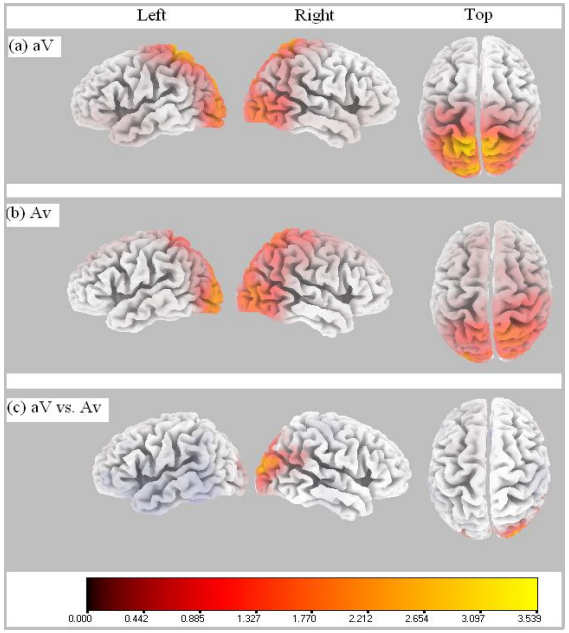
N1 Peak 170-190ms

注意视觉

注意听觉

统计差异



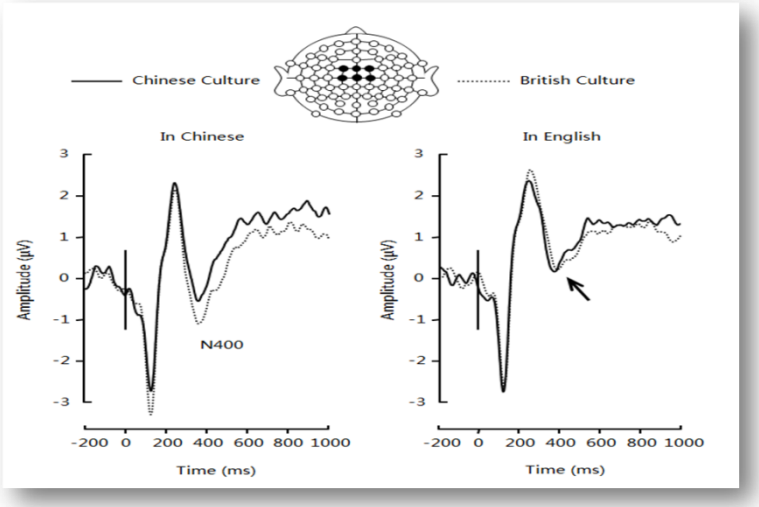


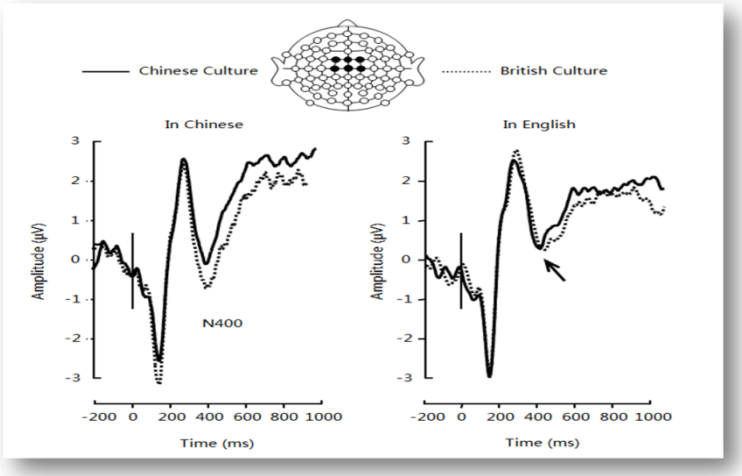
源分析支持效应在枕叶

不同的参考，可能导致截然不同的结果

Tian et al 2013 Psychophysiology

3. 语言文化效应研究 (英国班歌大学)





AR 发现：

存在语言主效应

存在文化主效应

存在文化与语言的交互效

REST 发现：

不存在语言主效应

存在文化主效应

存在文化与语言的交互效应

Guillaume Thierry

之前习惯于AR

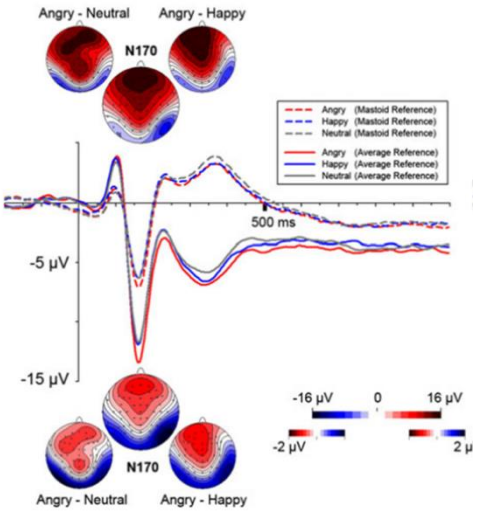
“产后来一碗鸡汤” （中国文化）

“产后来一支香烟” （西方文化）

研究者认为，REST 的结果更合理

Hu etal. In preparation

4. 情绪面孔识别特异性成分N170

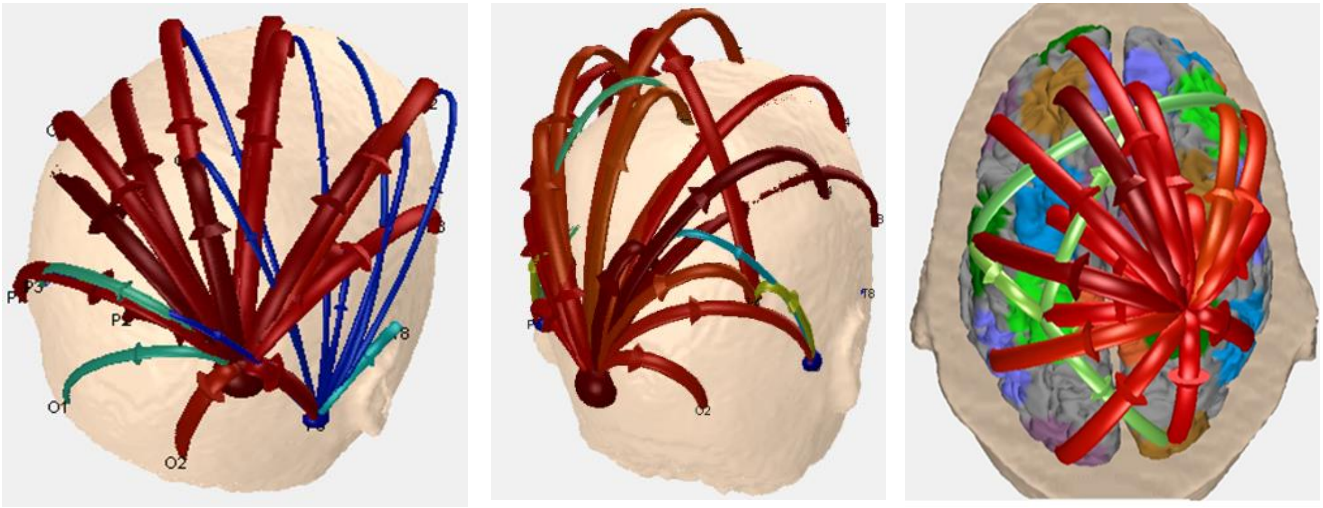


N170的解释存在参考相关争议

Rellecke et al., brain topography, 2013

头表网络

REST **AR** **cortex**



REST 网络更接近皮层网络，且更稳定

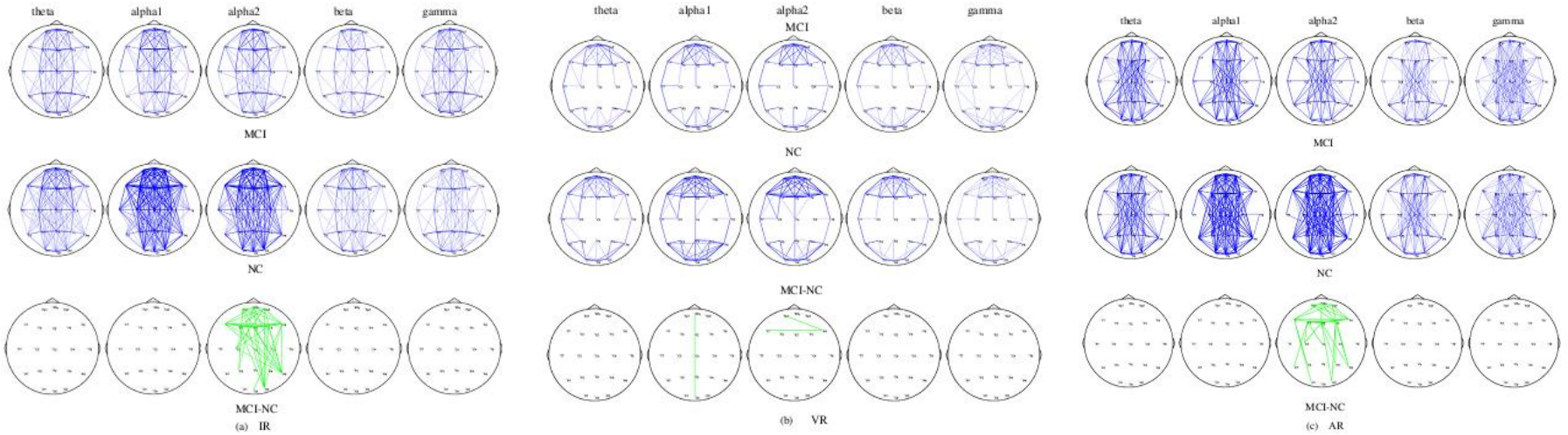
Tian etal. In preparation

REST与临床脑电？

“脑电是最主要的无创脑成像技术之一”

1. DMN of EEG， 区分 MCI and NC

不同参考(REST, 头顶， Average)，不同频段(delta,..,Gamma）情况下
MCI（轻度认知障碍）、NC（正常人）、MCI-NC的脑网络

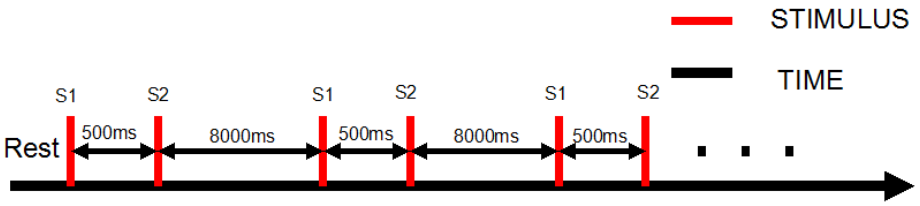


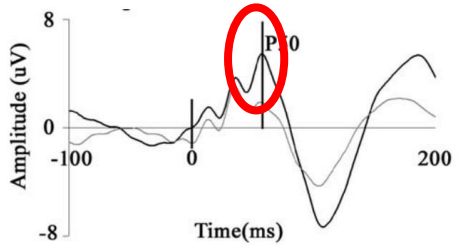
REST情况下的分类效果明显好于其它参考

		Alpha 1						Alpha 2						Alpha1+alpha 2					
		Acc (%)		Spe (%)		Sen (%)		Acc (%)		Spe (%)		Sen (%)		Acc (%)		Spe (%)		Sen (%)	
		NET	MCoh	NET	MCoh	NET	MCoh	NET	MCoh	NET	MCoh	NET	MCoh	NET	MCoh	NET	MCoh	NET	MCoh
LDA	VR	75	70	70	70	80	70	80	75	**90**	70	70	80	**90**	75	**100**	70		
	AR	65	70	60	70	70	70	85	75	80	70	90	80	75	75	70	70		
	IR	**85**	**80**	**80**	**80**	**90**	**80**	**90**	**85**	80	**80**	**100**	**90**	85	**80**	70	70		
SVM	VR	75	70	70	**70**	**80**	70	75	75	**80**	70	70	80	65	70	60	60		
	AR	75	65	70	50	**80**	**80**	80	70	70	60	90	80	75	65	70	50		
	IR	**80**	**75**	**80**	**70**	**80**	**80**	**90**	**85**	**80**	**80**	**100**	**90**	**85**	**75**	**80**	**80**		

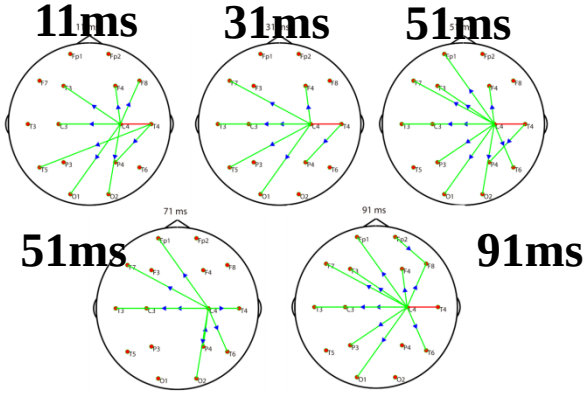
Xu etal. Physiol. Meas. 351279, 2014

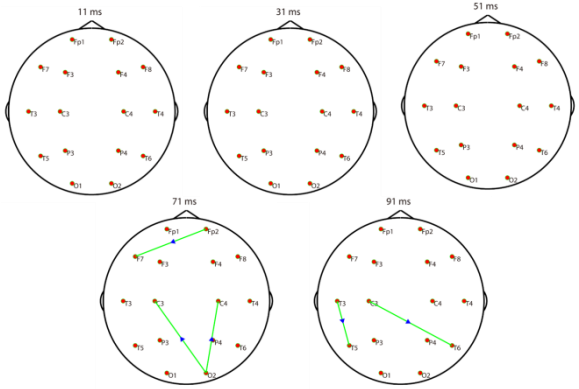
2. P50 difference between NC and SZ





Dynamic Network: S1 vs S2





NC（正常对照）: Significant difference

SZ: Non-Significant difference

SZ（精分）: 功能整合方面的Gating Filter Deficit

Li etal. In preparation

REST的地位？

“不缺位，不越位”

1.REST acts as Rosetta Stone in EEG domain

Kayser etal 2010 "In search of the Rosetta Stone for scalp EEG"

Ancient Egypt script
(unknow the meaning)

Modern Egypt language

制作于公元前196年，1799年于Rosetta城发现。刻有三种语言的古埃及国王诏书（古埃及象形文、当时的埃及通俗体文字，古希腊文字），其中前两种已经失传，通过现在能读的古希腊文字，破译了另外两种

Current EEG
(unknow the true EEG)

REST

True potential of EEG

2.REST can be adopted alone

3. What a change REST may induce?

- 颠覆性变化
- 原来不显著，变显著
- 原来显著的，变不显著
- 原来显著的，变更显著
- 原来不显著的，变更不显著

3. What a change REST may induce?

非真实脑电，变成真实脑电

真东西是唯一的

选择REST，就是选择真数据

Summary

- **Reference has distinct effect on waveform related parameters:**

  amplitude/ latency/coherence/network/spectra

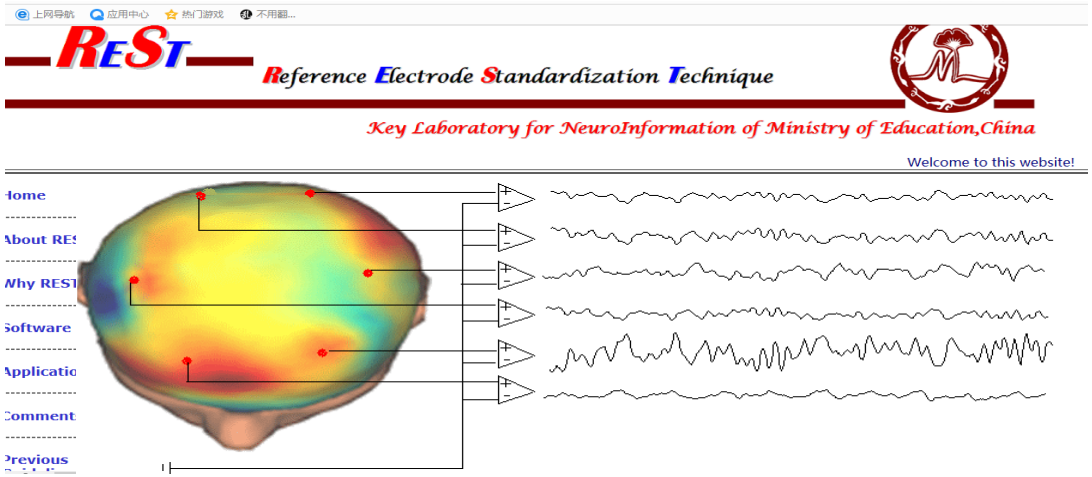
  /symmetry/covariance/statistic test..

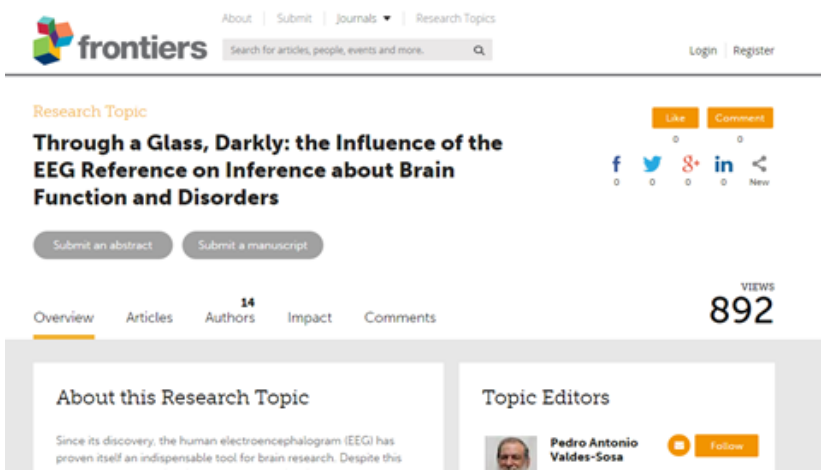
- **REST is the best one to approach to the idea zero**

www.neuro.uestc.edu.cn/REST

网站有多种版本的软件可以下载. 尤其最新推出的EEGLAB版本，可在EEGlab环境下非常方便的调用

Summary





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