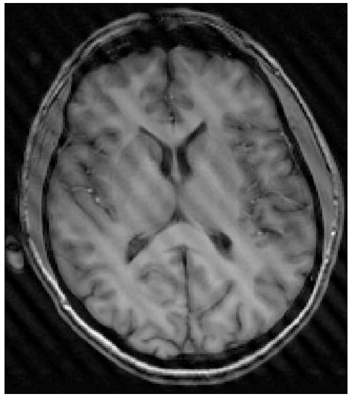
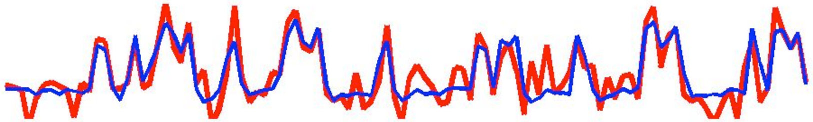
GLM stats
GLM统计





- An example experiment 一个示例实验
- Defining regressors 定义回归变量
- Contrasts 对比

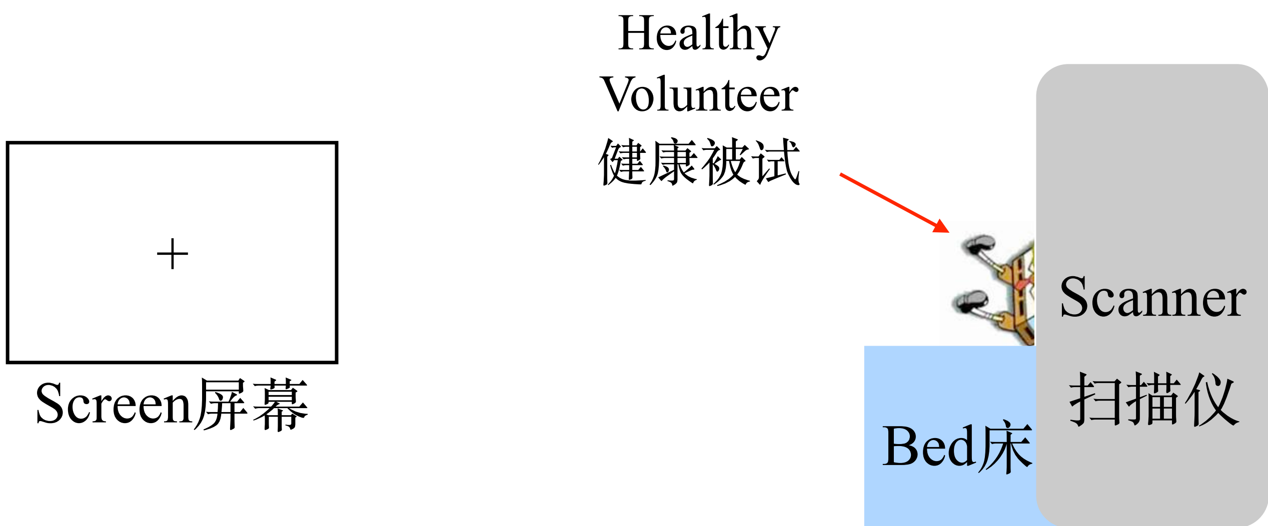
中文翻译：王继源 孔亚卓

Make sure you're awake! 保持清醒！

- When you see the sign below, I'm about to ask you something 当您看到下面的标志时，我将要问您一些问题
  - First I'll give you a minute to think about the answer by yourself 首先，我给您一点时间自己思考一下答案
  - Then I'll give you another minute to chat about the answer with each other 然后，我再给您一分钟的时间，讨论彼此的答案
  - After that, I'll give a brief explanation of the questions & answers 之后，我将简要说明问题和答案

Let's think!

Silent word generation 静音词生成



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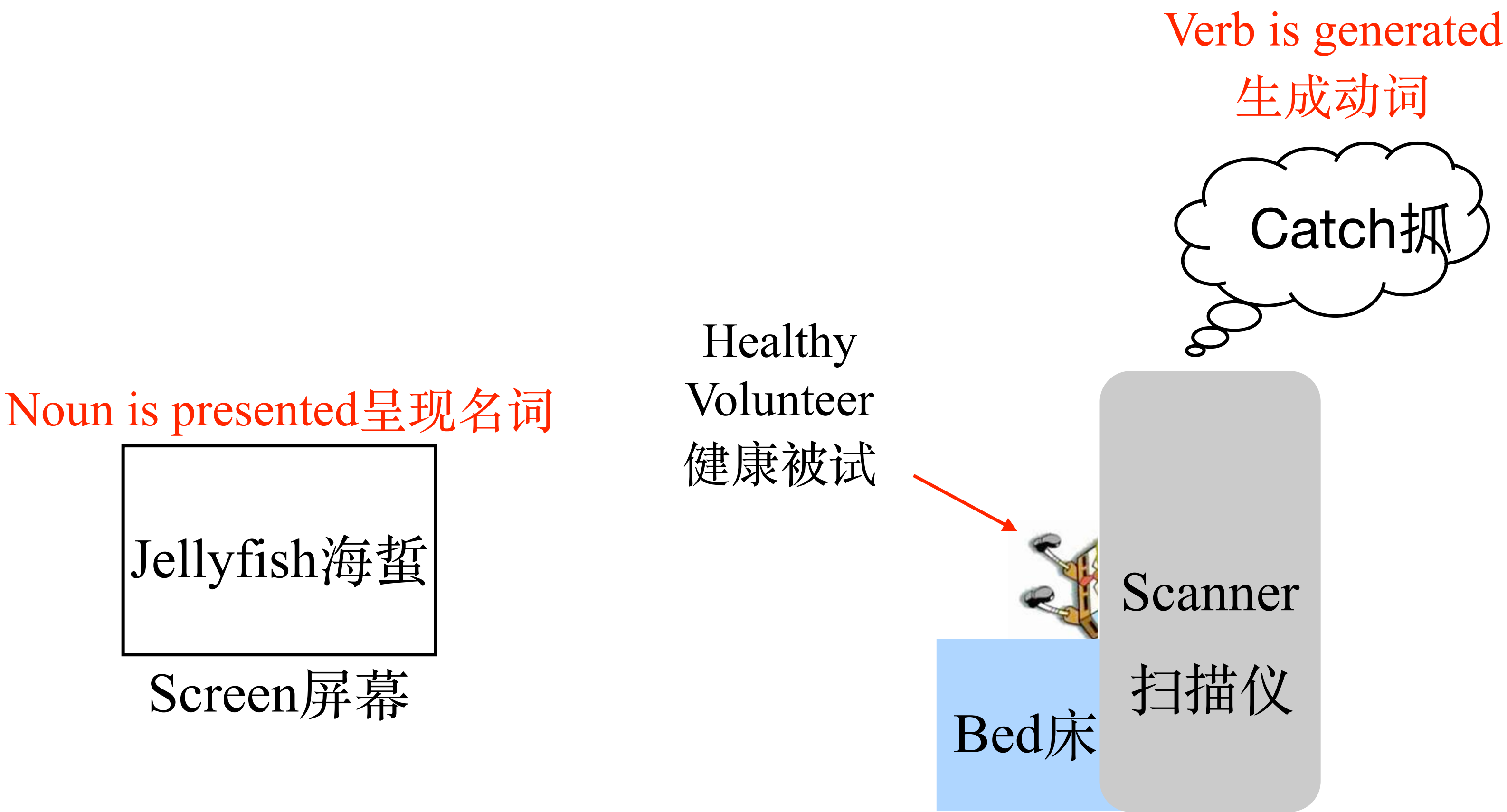
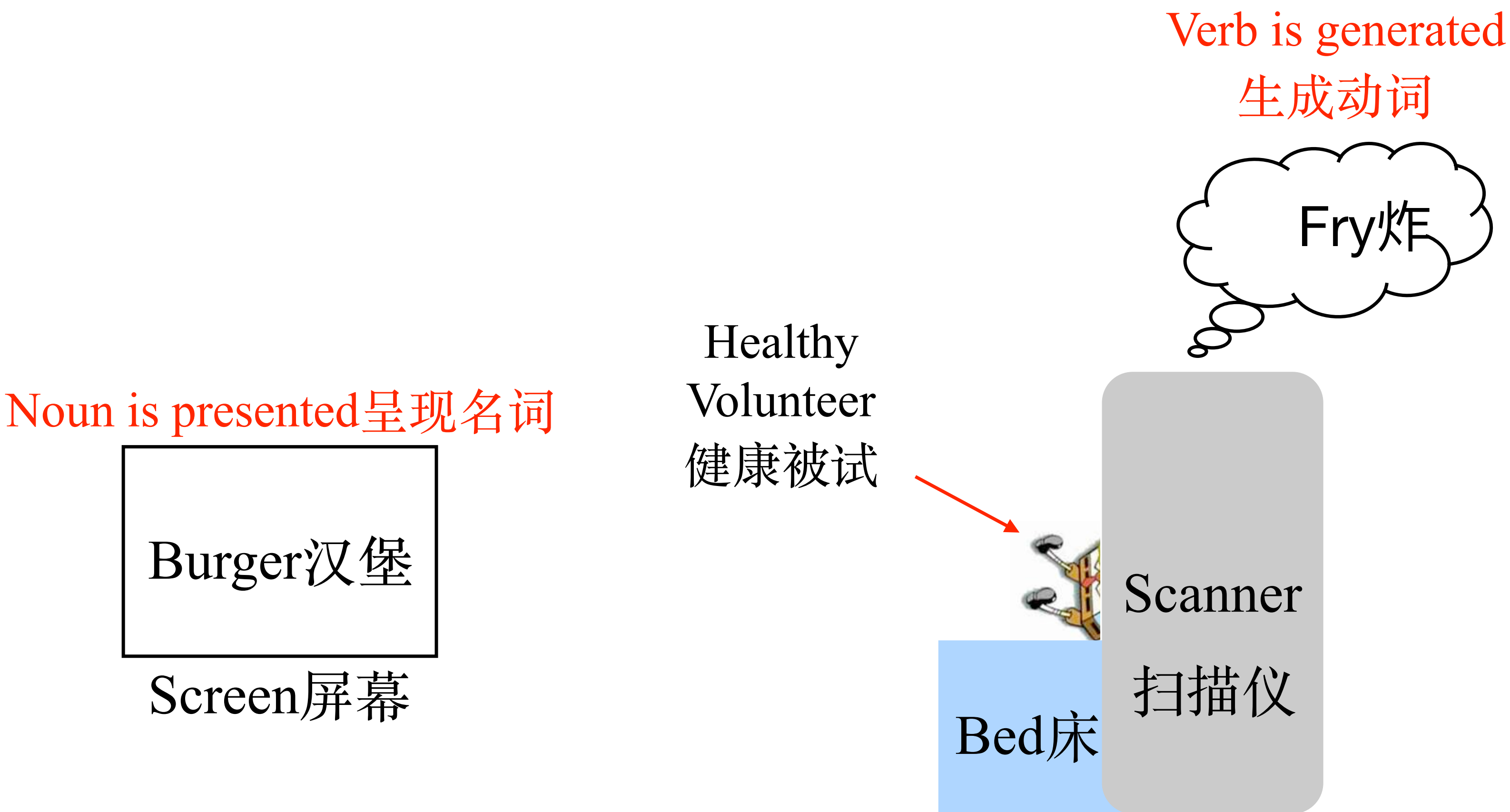
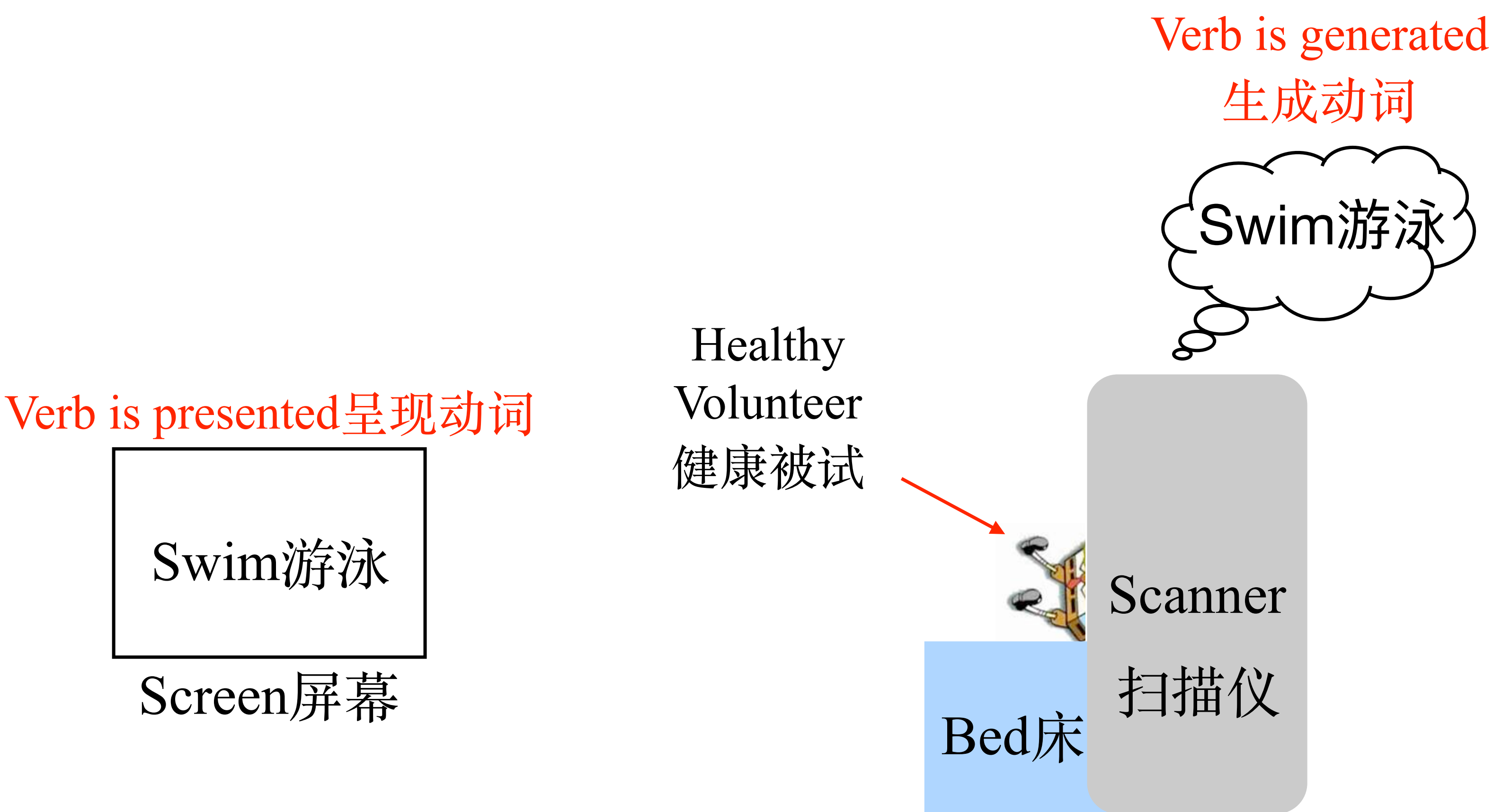


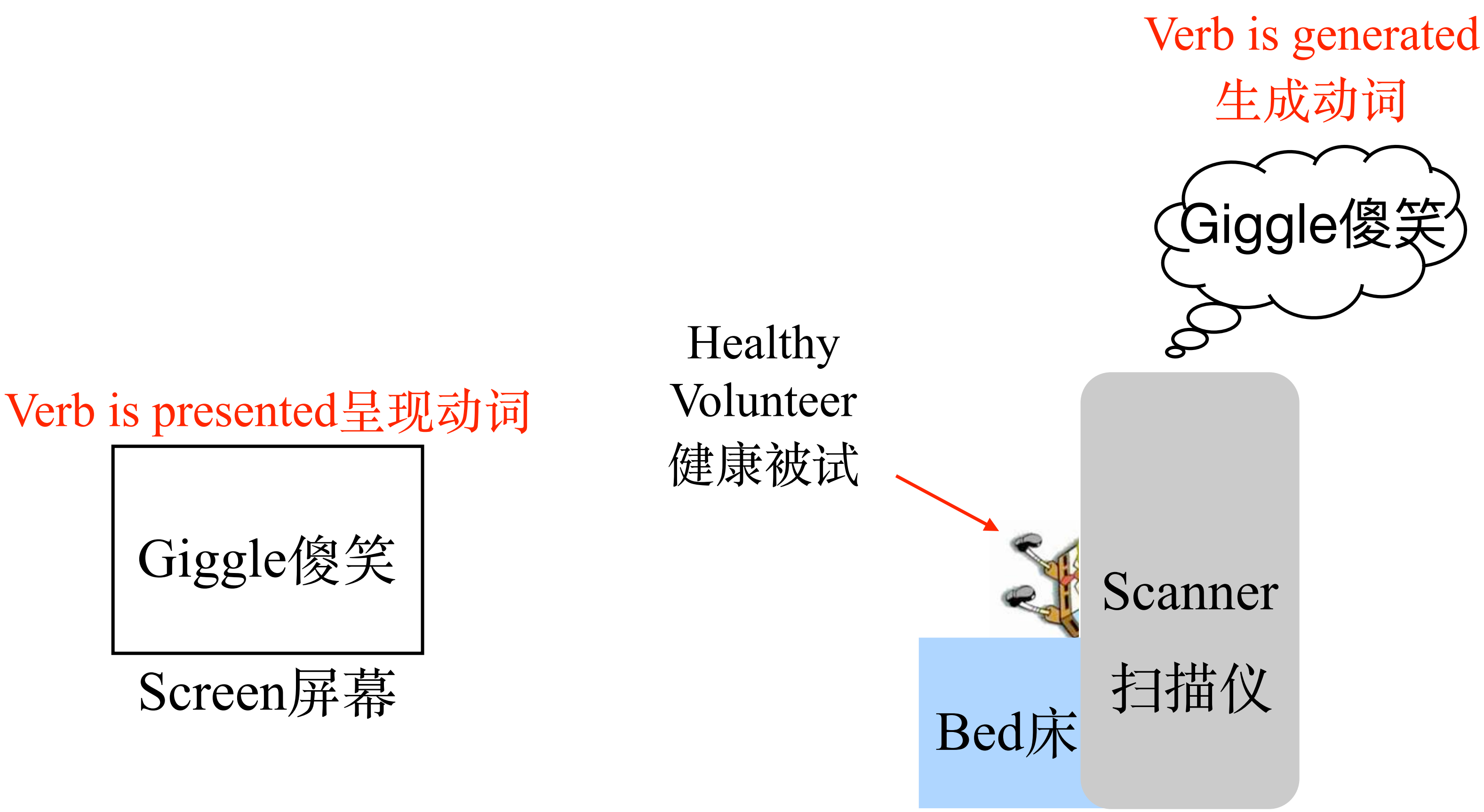
Silent word generation 静音词生成



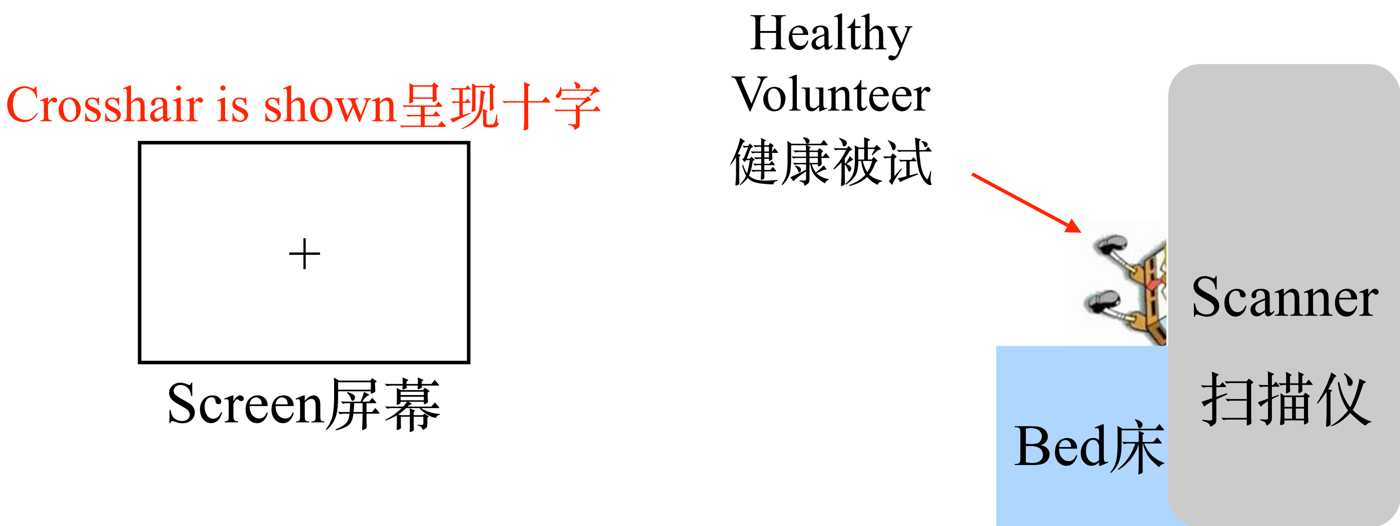
Control: silent word shadow 对照：静音词遮挡



Control: silent word shadow 对照：静音词遮挡

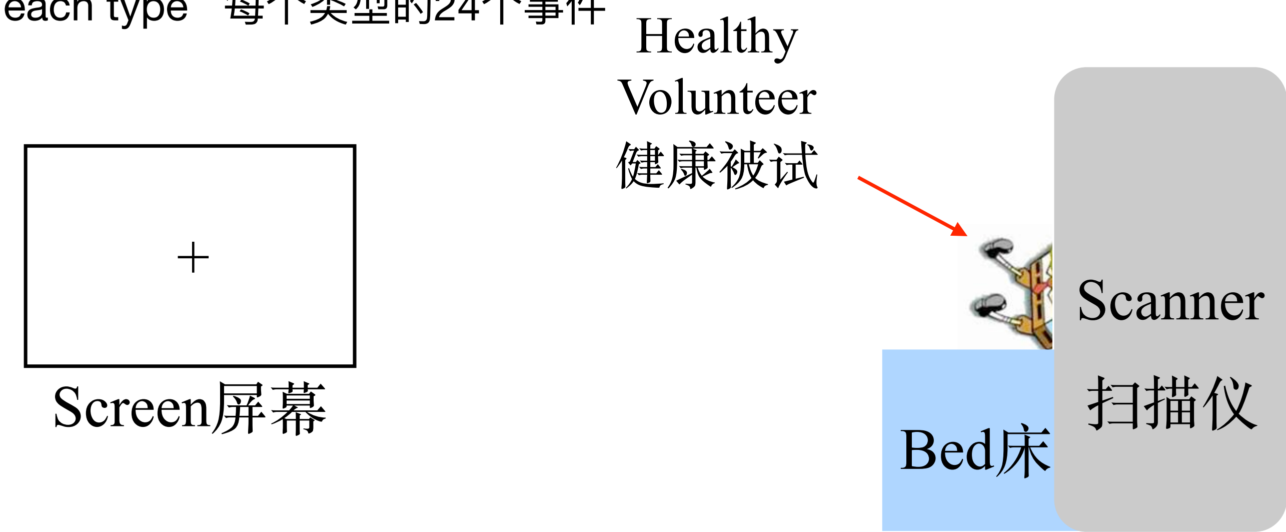


Baseline: crosshair 基线：十字



The full experiment 整个实验

- Three types of events 三种类型事件
  - 1st type: Word Generation 第一种：生成词
  - 2nd type: Word Shadowing 第二种：遮挡词
  - 3rd type: Null event 第三种：空事件
- 6 sec ISI, random order 6s时间间隔，随机
- 24 events of each type 每个类型的24个事件



How to analyze the data? 怎么分析数据

1. Set up regressors 设置回归量

   What do we know the brain should be doing during the experiment? 我们知道实验期间大脑应该做什么?

   = *Explanatory variables, Design Matrix, Model* 解释变量，设计矩阵，模型

2. Fit the regressors to the data 根据数据拟合变量

   Combine the regressors in a way that is most similar to the observed data以与观察到的数据最相似的方式组合回归变量

   = *Parameter Estimates (PE), Betas, Effect Sizes* 参数估计（*PE*），贝塔系数，效应量

3. Set up contrasts to compare conditions 设置对比条件

   Compare conditions by doing simple arithmetic 通过简单的算数比较条件

   = *Contrast of Parameter Estimates (COPE)* 参数估计对比向量（*COPE*）

4. Perform statistical inference (Covered this afternoon) 统计推断（下午讨论）

   Often t-test to see if COPE is bigger than zero 经常进行t检验，以了解COPE是否大于零

Let’s think!
思考一下

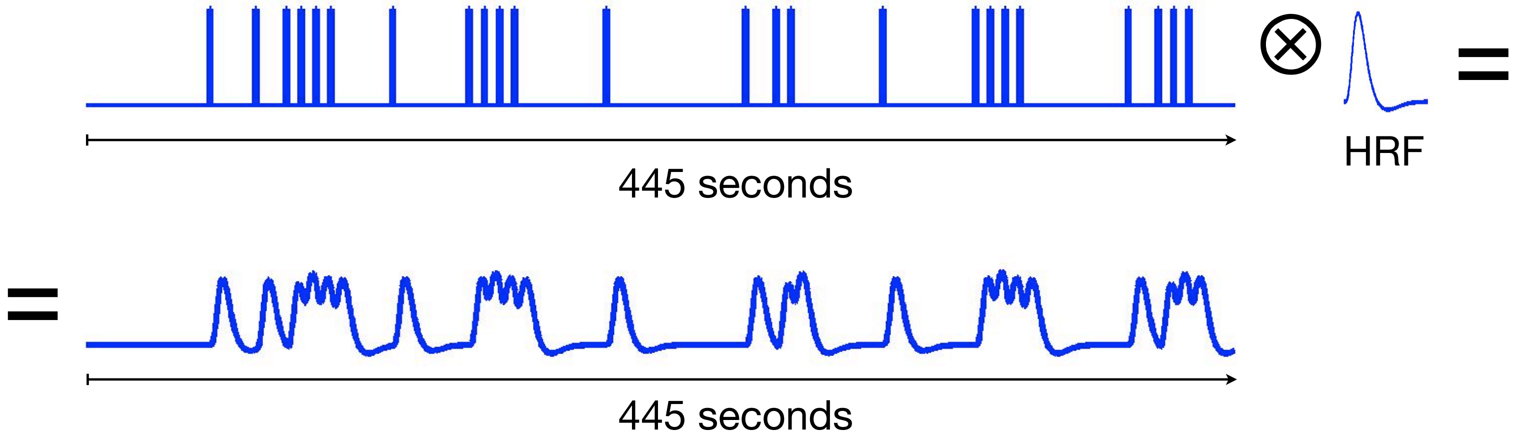
Before we learn more, which of these familiar steps would happen before the GLM? 在我们进一步了解之前，以下哪些熟悉的步骤将在GLM之前发生?

1. Motion correction 头动校正
2. Slice timing correction 时间层校正
3. Estimating transformation to MNI space 估算向MNI空间的变换
4. Applying transformation to MNI space 使用向MNI空间的变换

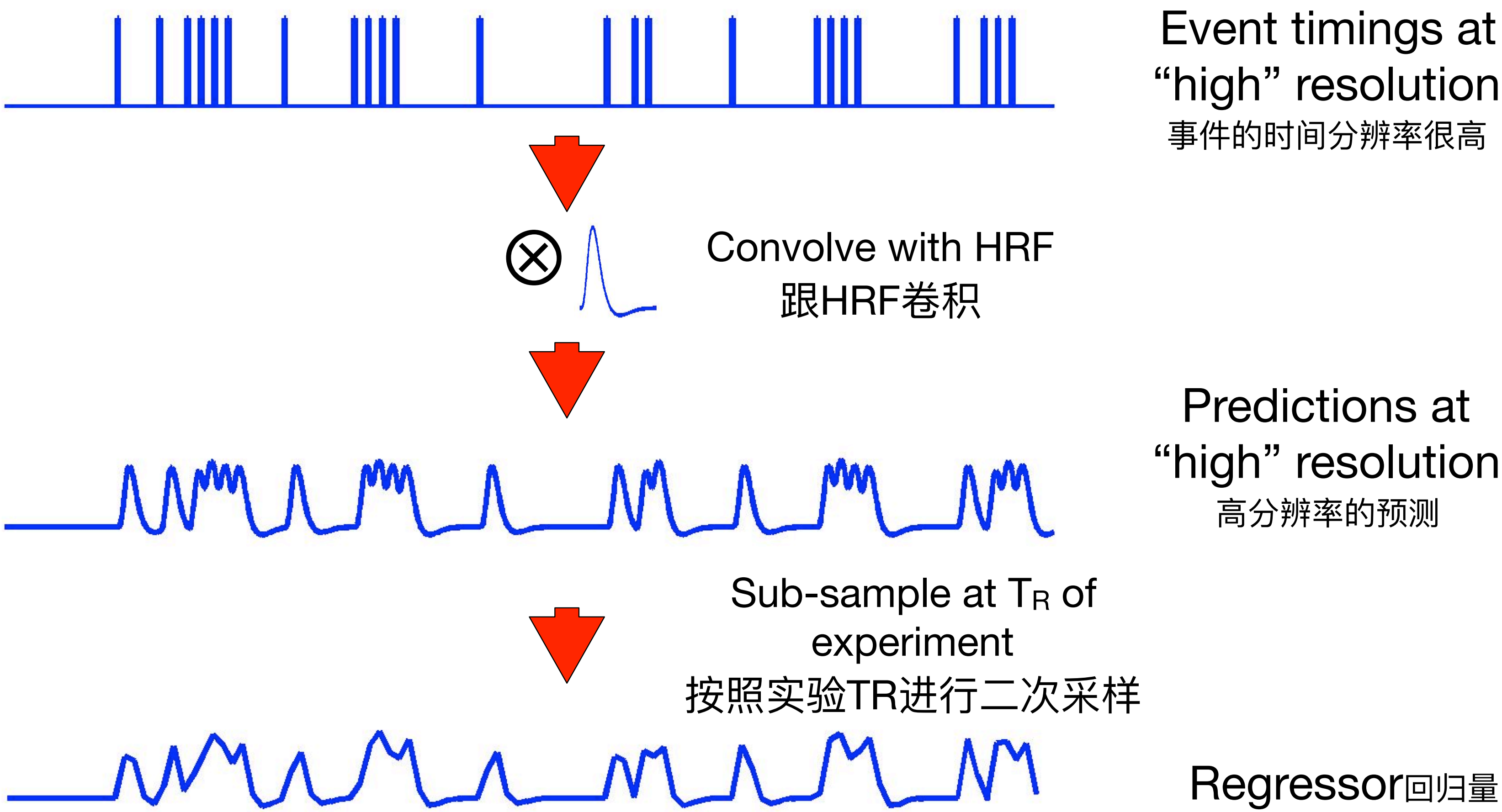
Defining regressors 定义回归量

Predicted response to word generation

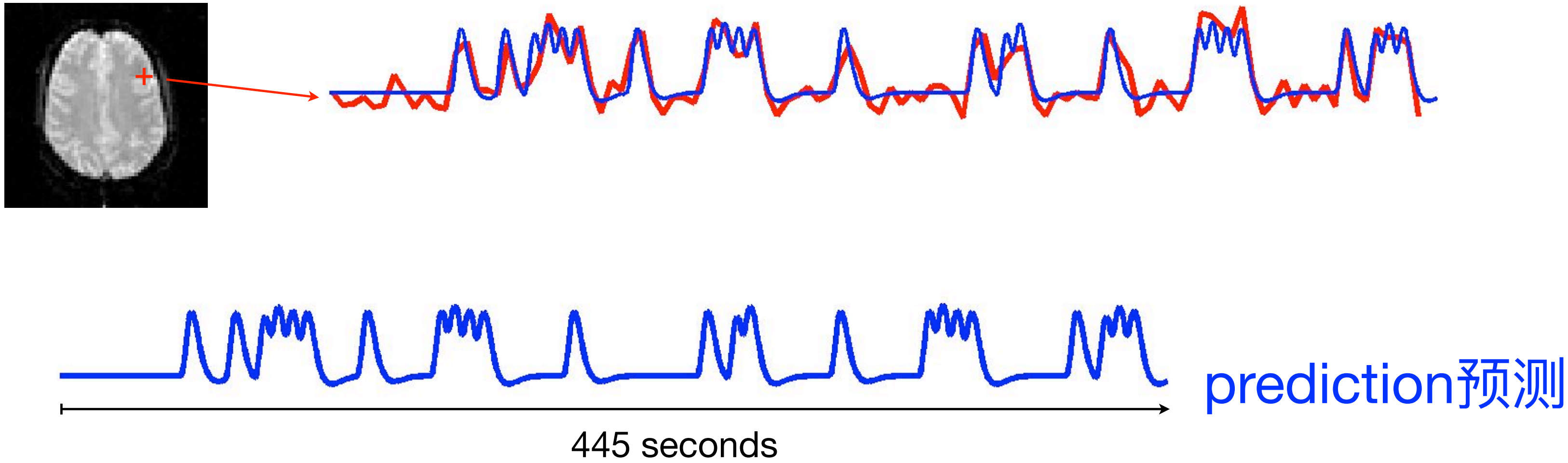
预测产生词的响应



Subsampling to TR 按TR二次采样



Voxel-wise analysis 基于体素的分析



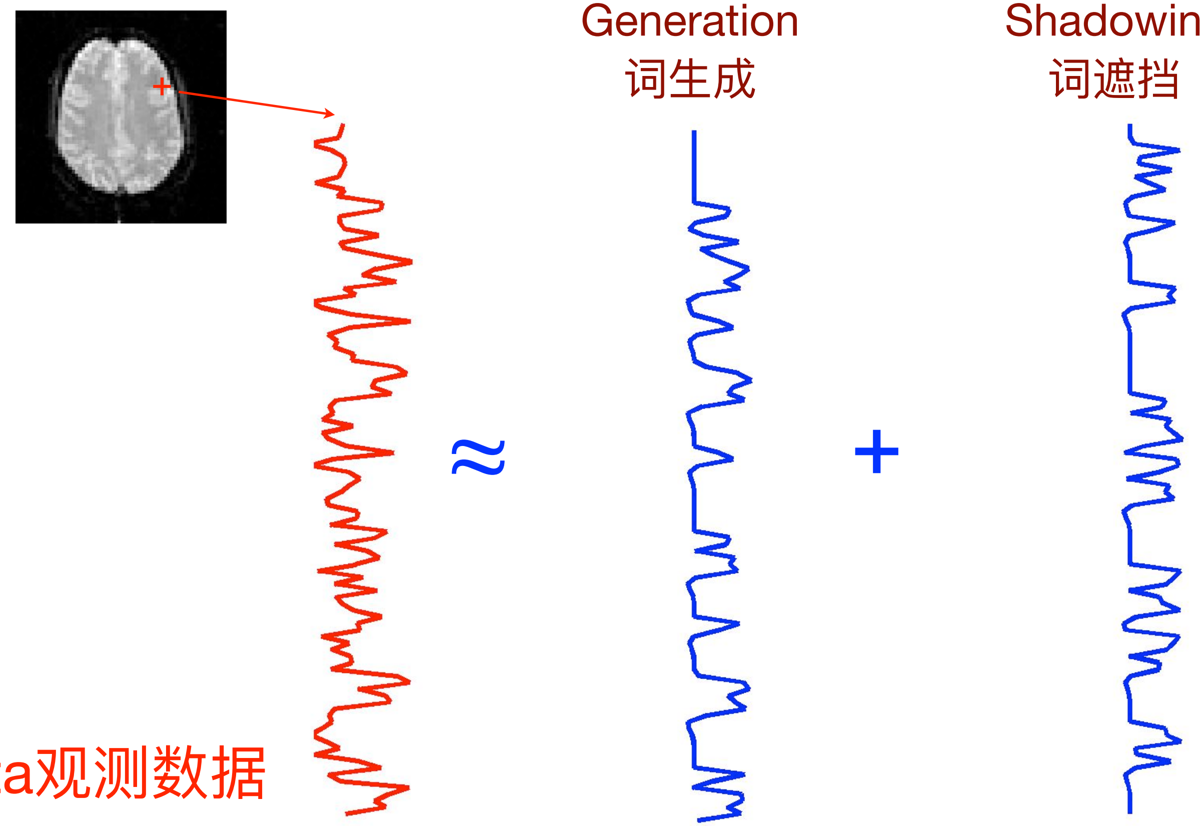
Looking for voxels interested in during word generation
寻找在词生成中感兴趣的体素

Your new friend: the GLM

你的新朋友：一般线性模型

Word
Generation
词生成

Word
Shadowing
词遮挡



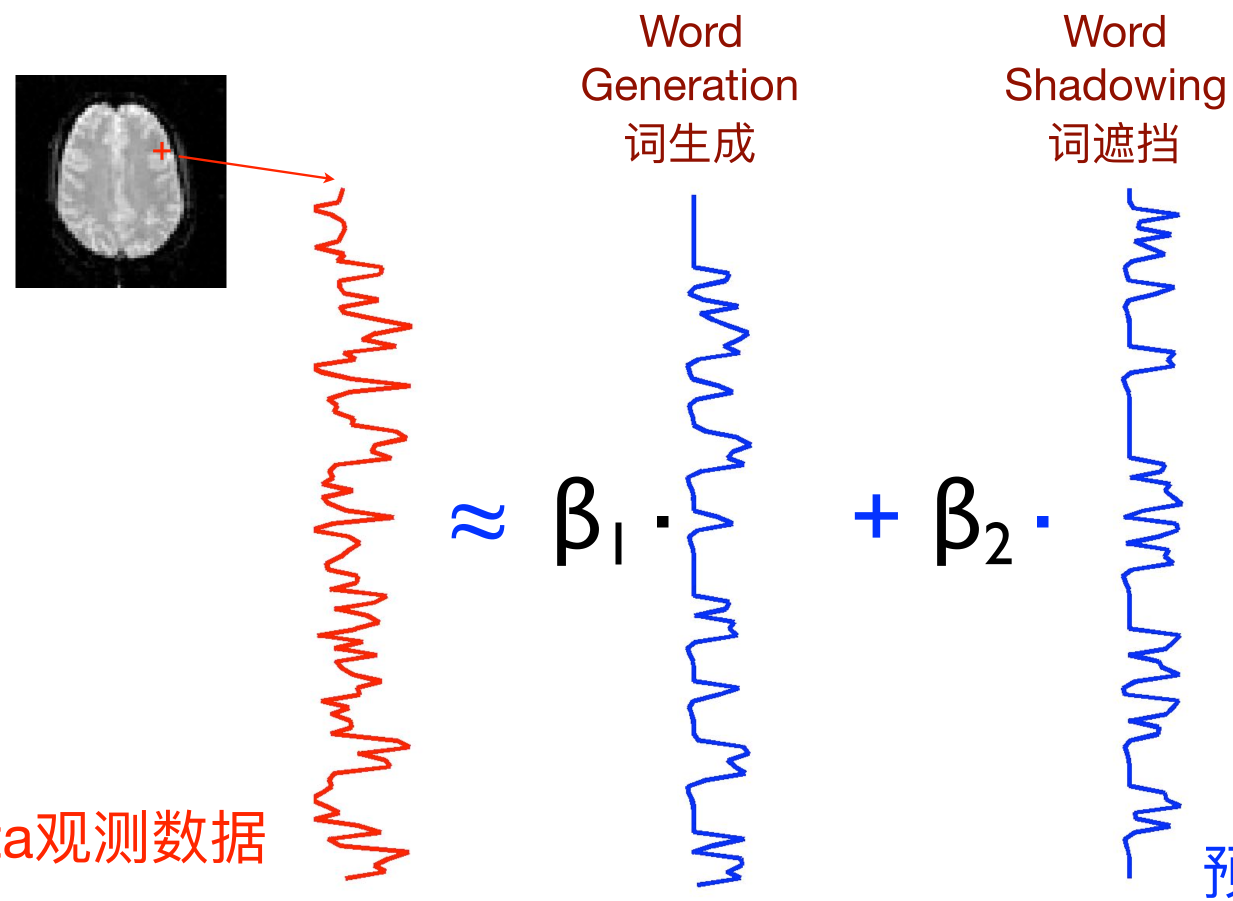
Observed data观测数据

Predicted responses
= EVs = regressors
预测响应=EVs=回归量

What about baseline? 有关基线

- The mean BOLD value is uninteresting in an FMRI session
  在一组FMRI数据中，平均BOLD值没有意义
- There are two equivalent options 有两个等效选项:
  1. Remove the mean from the data and don't model it (FSL 1st level; i.e. a regressor for the baseline is not included)
     从数据中去除均值并且不对其建模（FSL 的第一阶分析；即不包括基线的回归变量）
  2. Model the mean (FSL group & SPM 1st level + group)
     建模平均值（FSL组分析&SPM的第一阶+组分析）

Parameter Estimates 参数估计



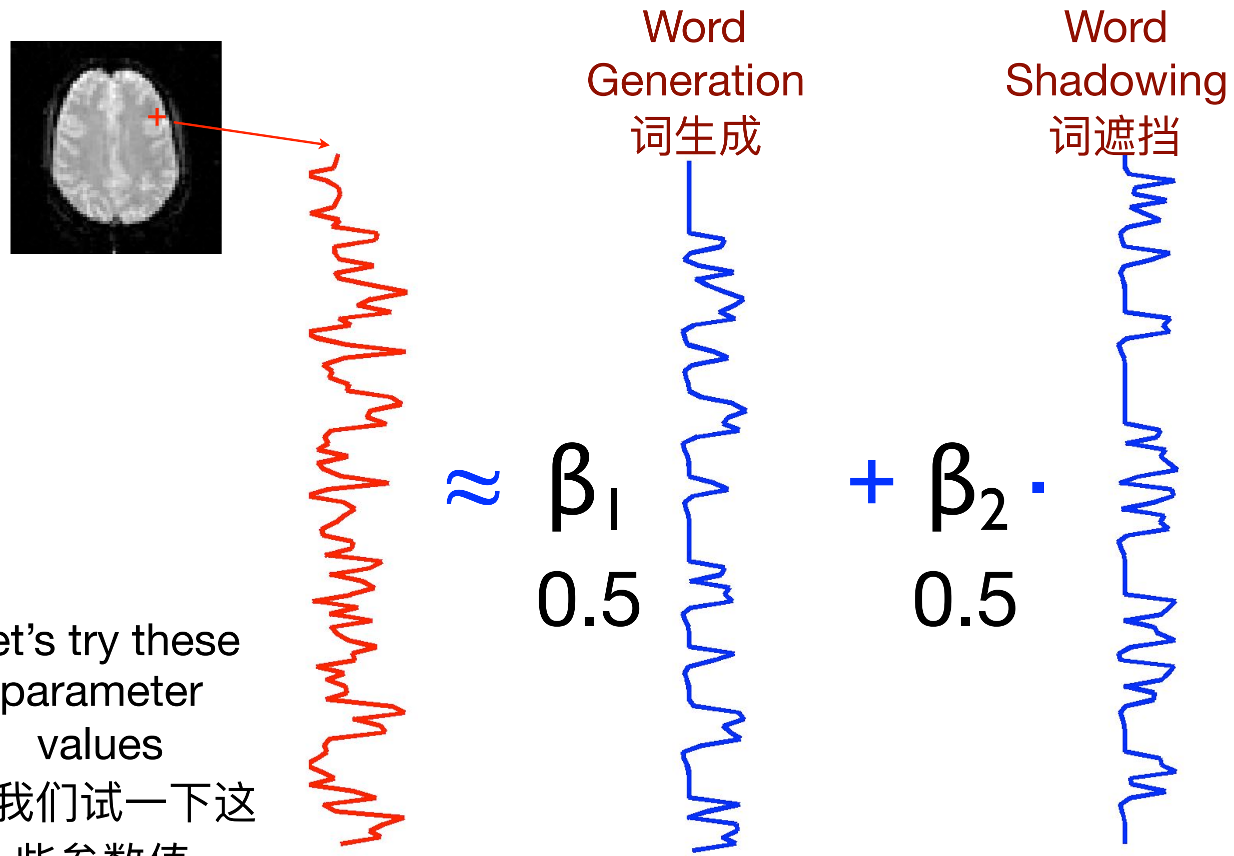
Observed data观测数据

Predicted responses
= EVs = regressors
预测响应=EVs=回归变量

Estimation: finding a good fit 估算：找到好的拟合

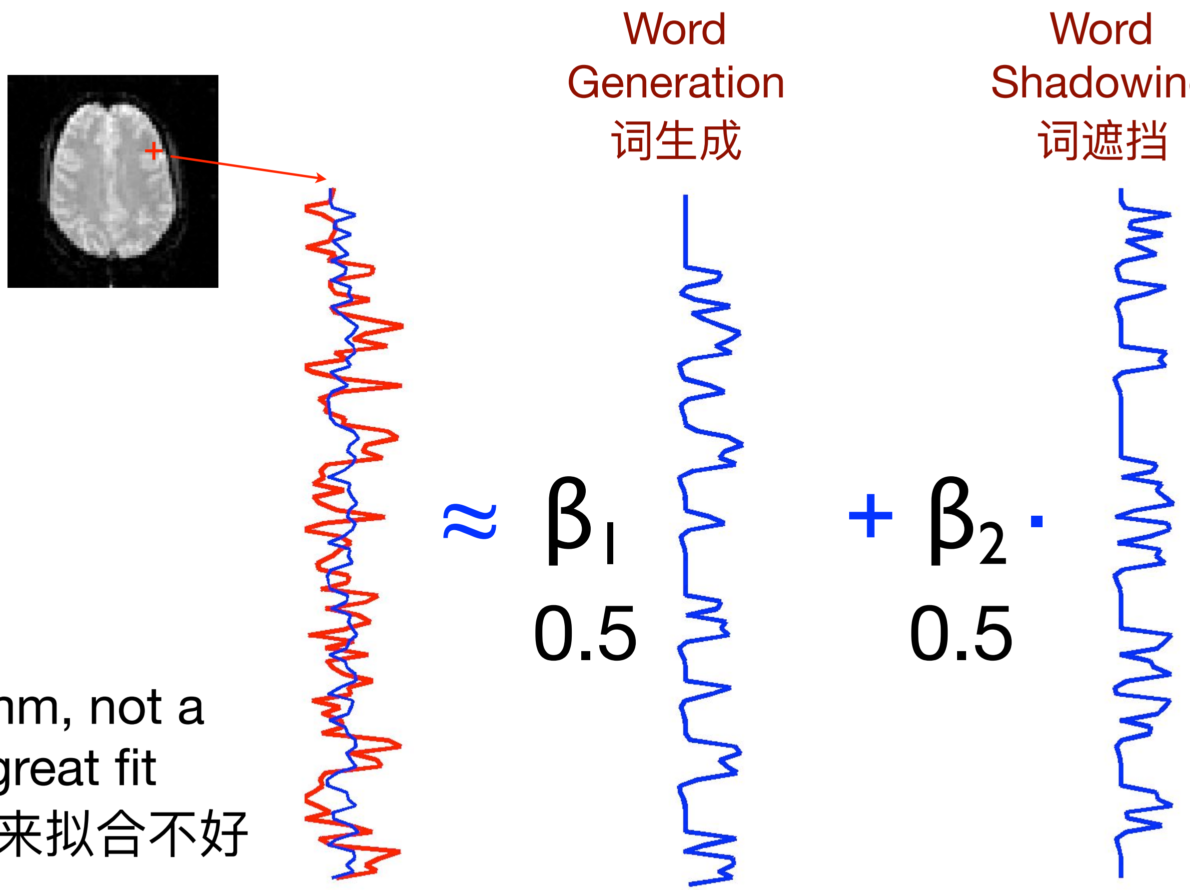
The estimation entails finding the parameter values such that the linear combination “best” fits the data

估算需要找到参数值，以使线性组合“最佳”的拟合数据



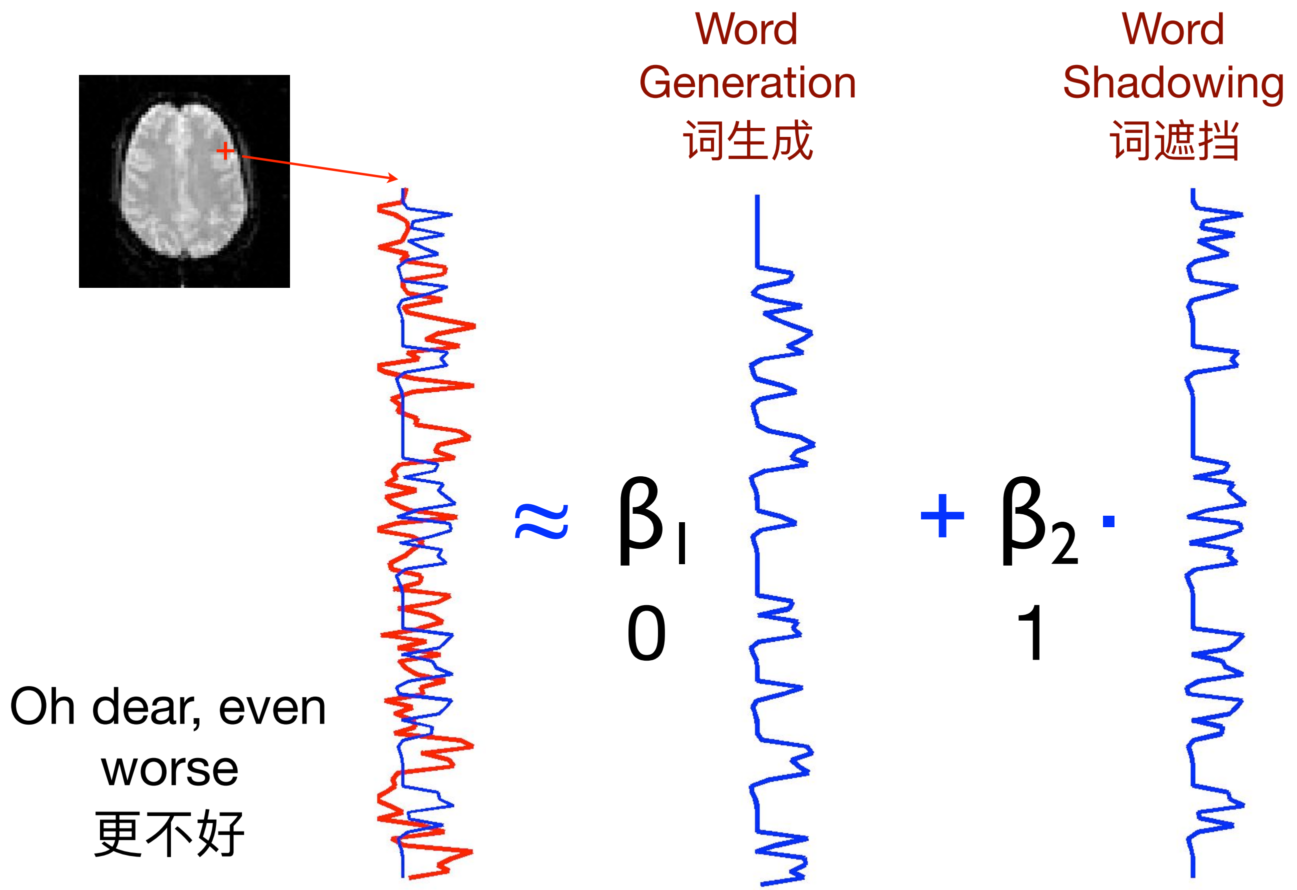
Let’s try these parameter values
让我们试一下这些参数值

Estimation: finding a good fit 估算：找到好的拟合

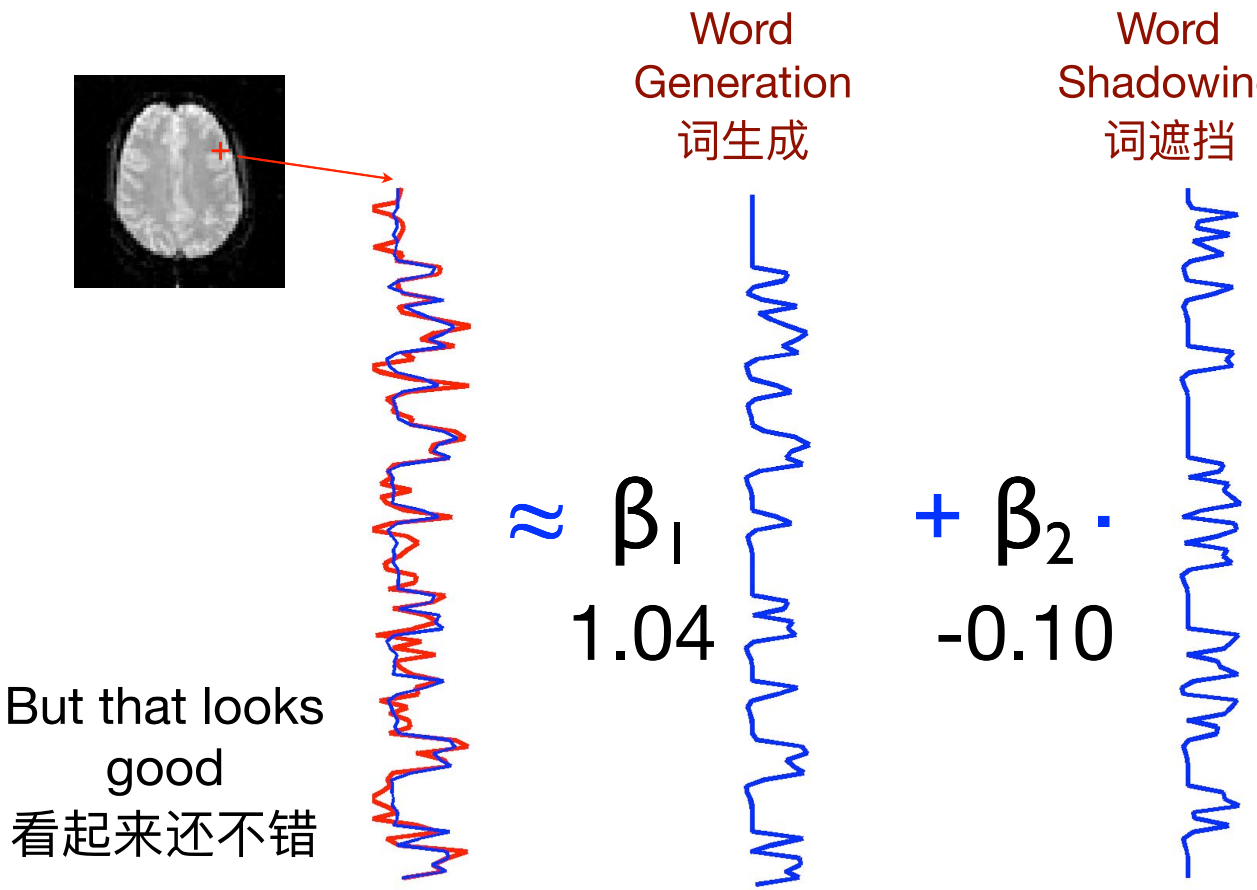


Hmm, not a great fit
看起来拟合不好

Estimation: finding a good fit 估算：找到好的拟合

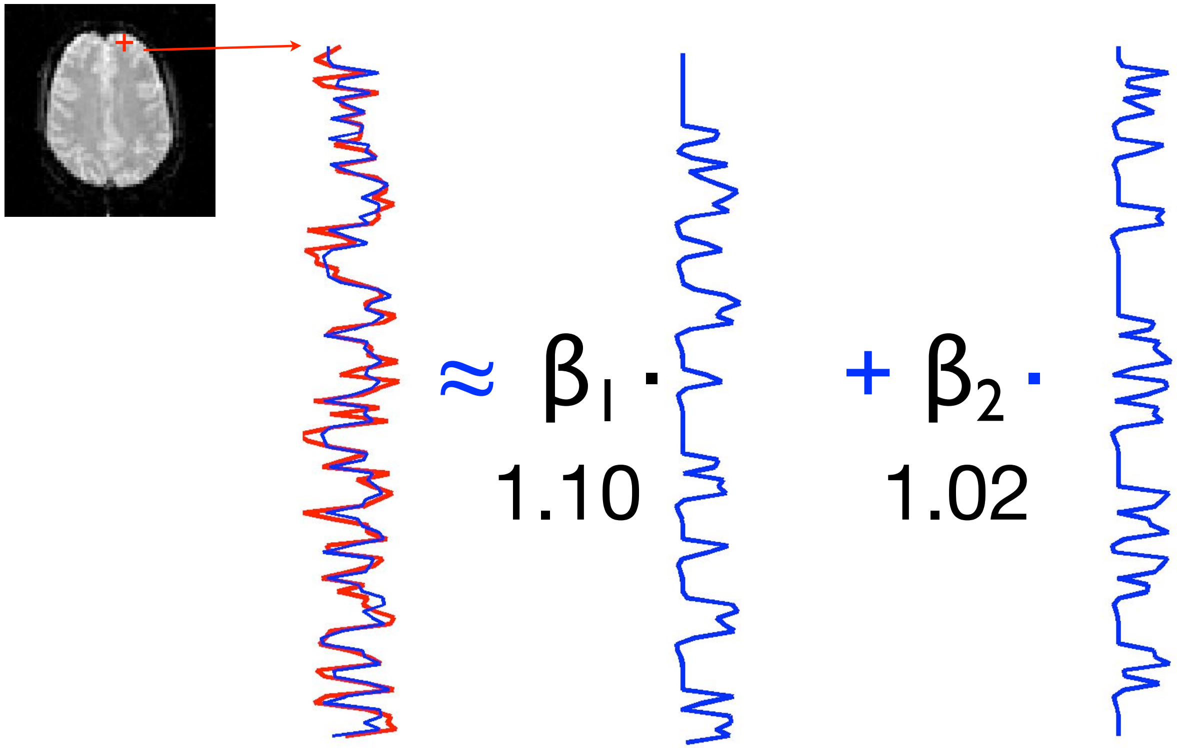


Estimation: finding a good fit 估算：找到好的拟合



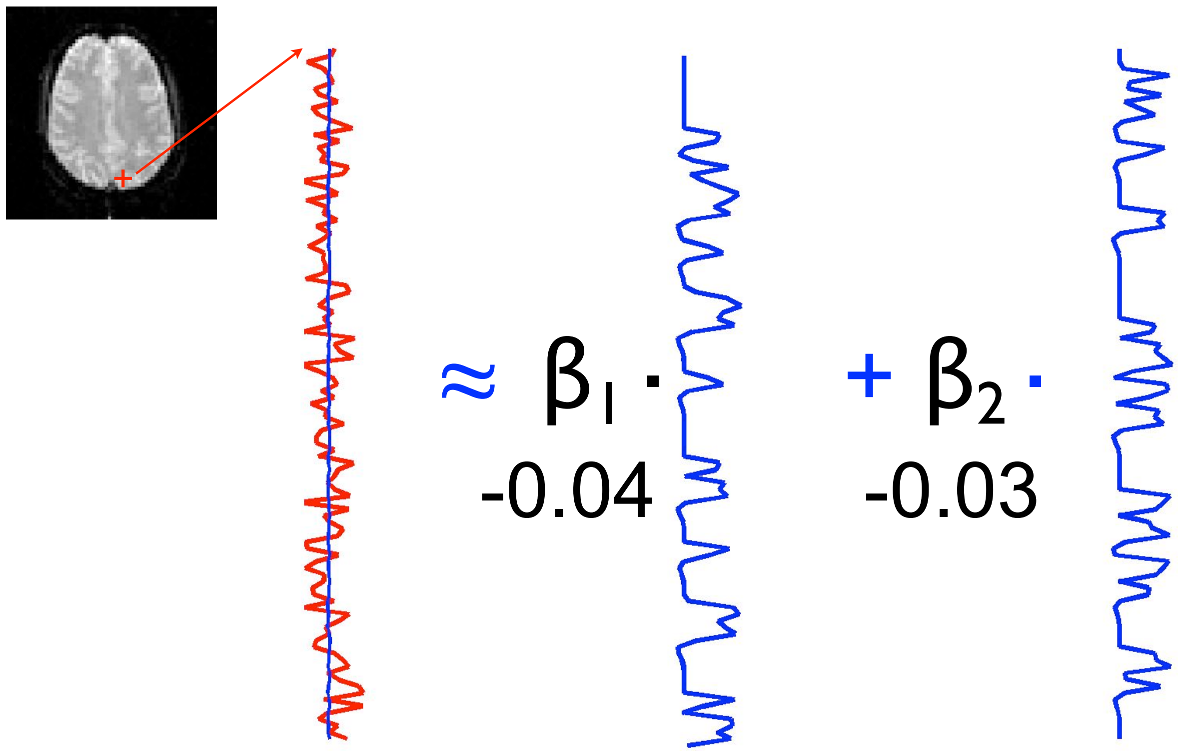
Estimate PEs separately for each voxel

分别估算每个体素的PE

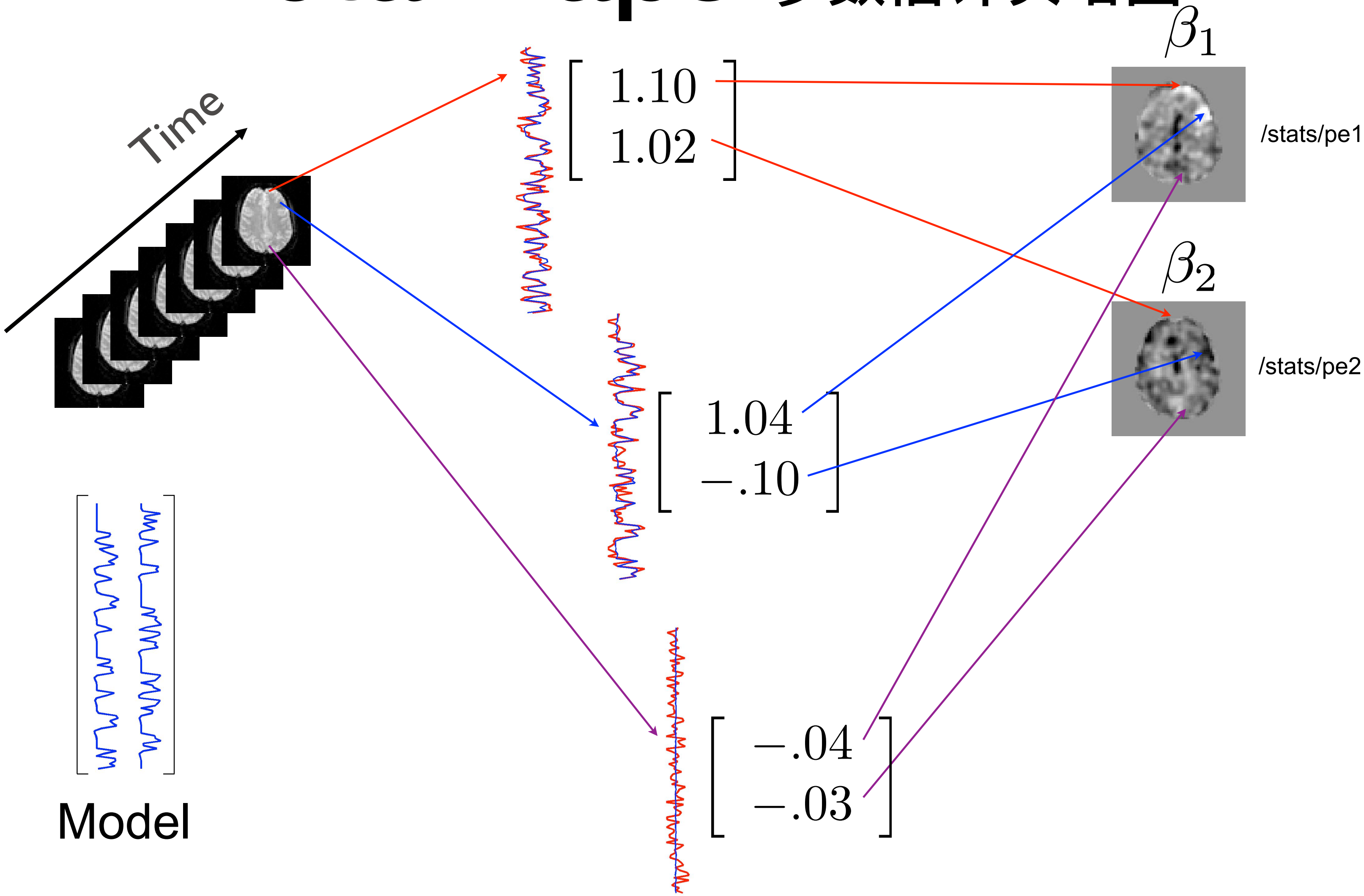


Estimate PEs separately for each voxel

分别估算每个体素的PE



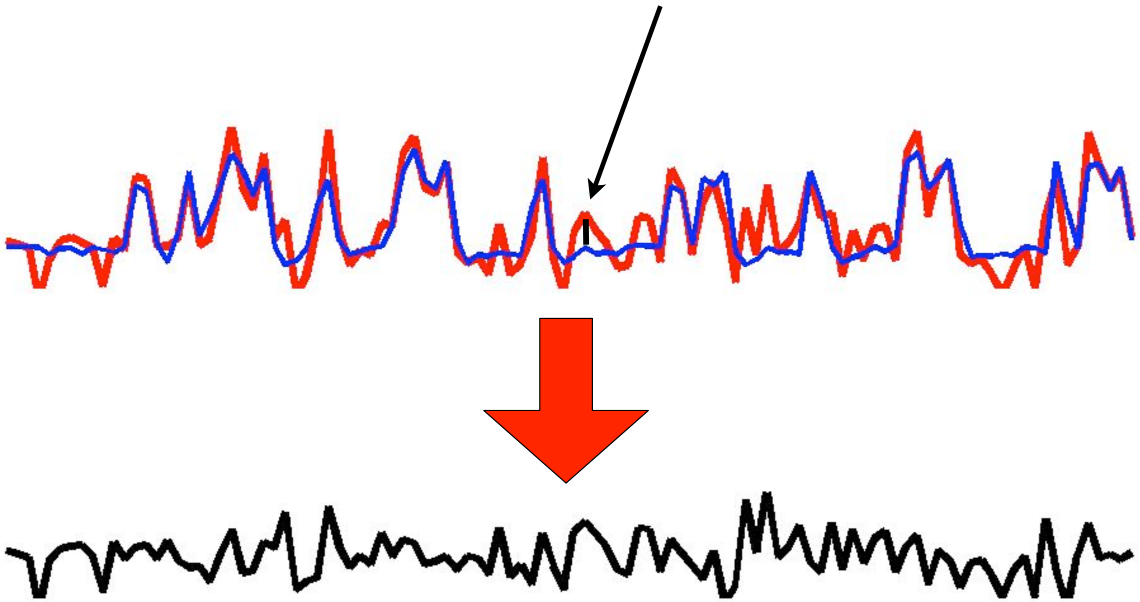
Beta maps 参数估计贝塔图



Residuals 残差

Difference between data and best fit: “Residual error”

数据与最佳拟合之间的差异：“残差”



Residual errors

残差

↕ σ Used to calculate t-statistic

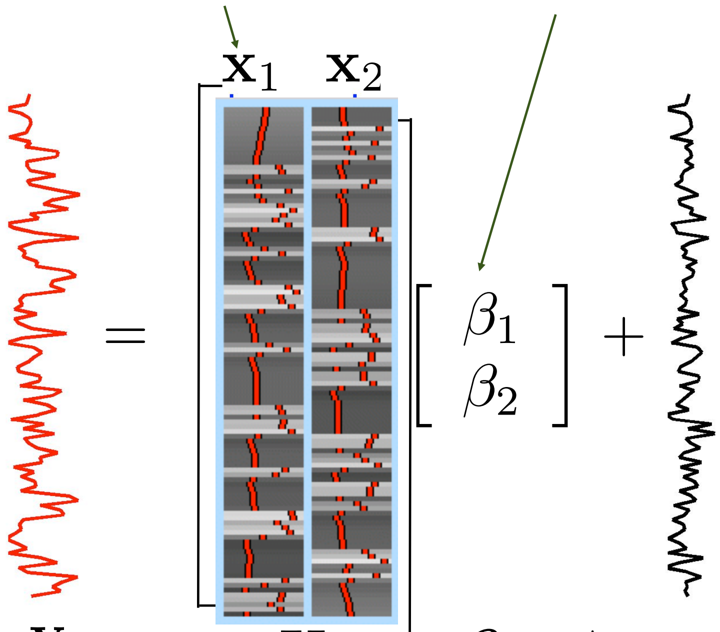
用于计算t-统计

The GLM framework

GLM框架

Regressor 回归变量
Explanatory Variable 解释变量(EV)

Regression parameters 回归参数
Effect sizes 效应量



$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{e}$$

Data from a voxel
某体素的数据

Design Matrix
设计矩阵

Gaussian noise
(temporal autocorrelation)
高斯噪音（时域自相关）

Let’s think!
思考一下！

Your pain study has pin-pricks to the left foot, right foot, left arm and right arm & rest periods

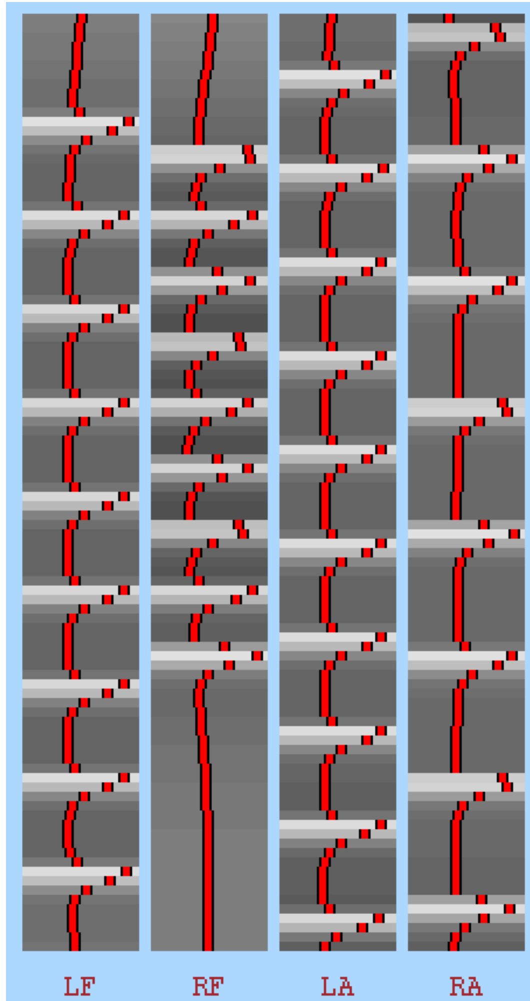
你的疼痛研究包含对左右脚，左右胳膊的针刺刺激，还有休息阶段

1. How many EVs will you set up in your design?

   你在设计中设置多少个EV?

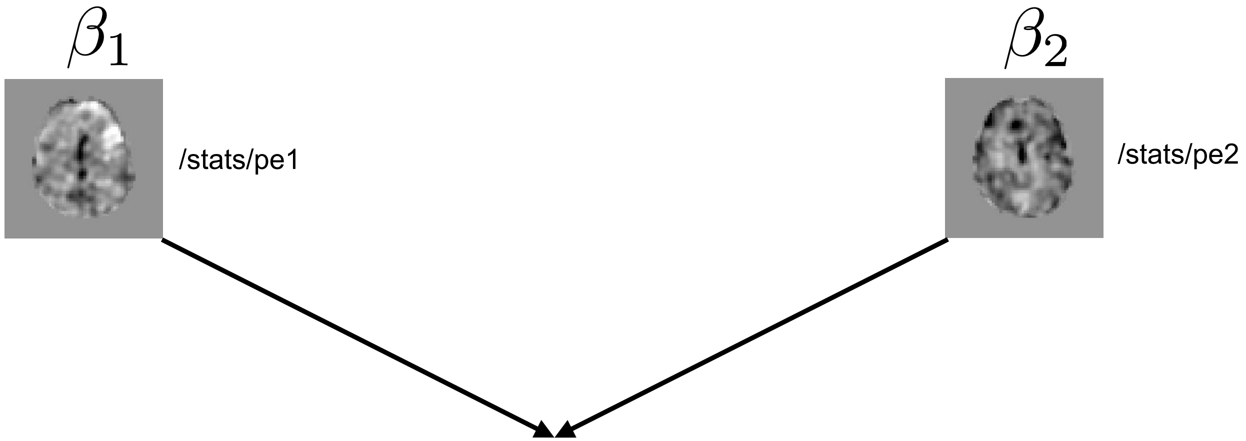
2. Draw or write out what the EVs would look like (just make up stimulus timings)

   画出或写出EV的外观（只是排一下刺激的时间）



Contrasts 对比

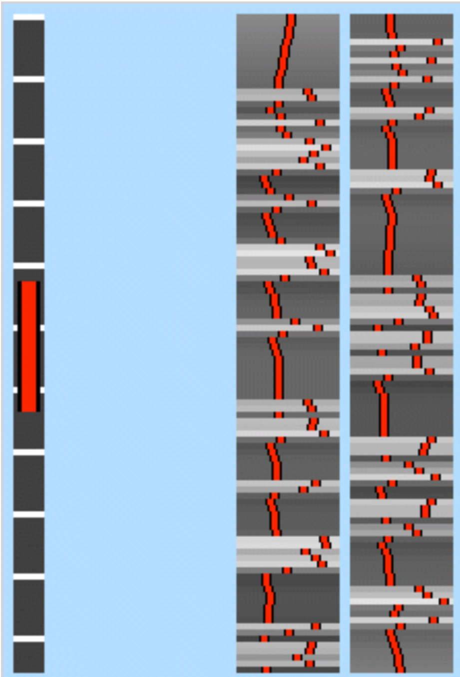
Research questions 研究问题



Which areas of the brain are significantly activated during word generation compared to baseline? 与基线相比，词生成过程中大脑的哪些区域被显著激活?

Which areas of the brain are significantly more activated during word generation compared to word shadowing? 与词遮挡相比，词生成过程中大脑的哪些区域的激活明显更多?

Possible contrasts 可能的对比



		Gen	Shad
C1	Generation	1	0
C2	Shadowing	0	1
C3	Mean	1	1
C4	Shad > Gen	-1	1
C5	Gen > Shad	1	-1

- [1 0] : EV1 vs baseline

  EV1对基线

- [0 1] : EV2 vs baseline

  EV2对基线

- [1 1] : Mean of EV1 and EV2

  EV1和EV2平均

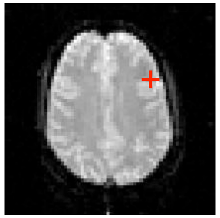
- [-1 1]: More activated in EV2 than EV1

  EV2比EV1激活更多的部分

- [1 -1]: More activated in EV1 than EV2

  EV1比EV2激活更多的部分

COPEs = simple arithmetic 简单算数



$\beta_1 = 1.04$

$\beta_2 = -0.10$

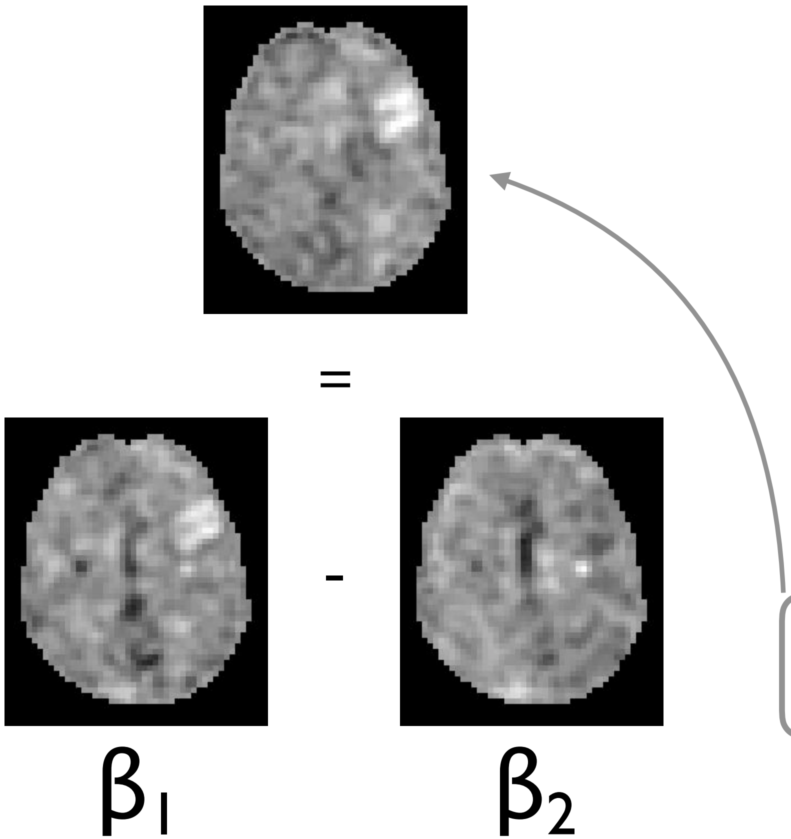
Use t-test to determine if COPE is significantly greater than zero

使用t检验确定COPE是否显著大于零

- [1 0] : 1 x 1.04 + 0 x -0.10 = 1.04
- [0 1] : 0 x 1.04 + 1 x -0.10 = -0.10
- [1 1] : 1 x 1.04 + 1 x -0.10 = 0.94
- [-1 1]: -1 x 1.04 + 1 x -0.10 = -1.14
- [1 -1]: 1 x 1.04 + -1 x -0.10 = 1.14

COPE images

COPE图像



- [1 0] : 1 x 1.04 + 0 x -0.10 = 1.04
- [0 1] : 0 x 1.04 + 1 x -0.10 = -0.10
- [1 1] : 1 x 1.04 + 1 x -0.10 = 0.94
- [-1 1]: -1 x 1.04 + 1 x -0.10 = -1.14
- [1 -1]: 1 x 1.04 + -1 x -0.10 = 1.14

F-contrasts
F-对比

- Allows you to ask if any condition is significant

允许你知道那种条件是显著的

  - Is there activation to any condition?

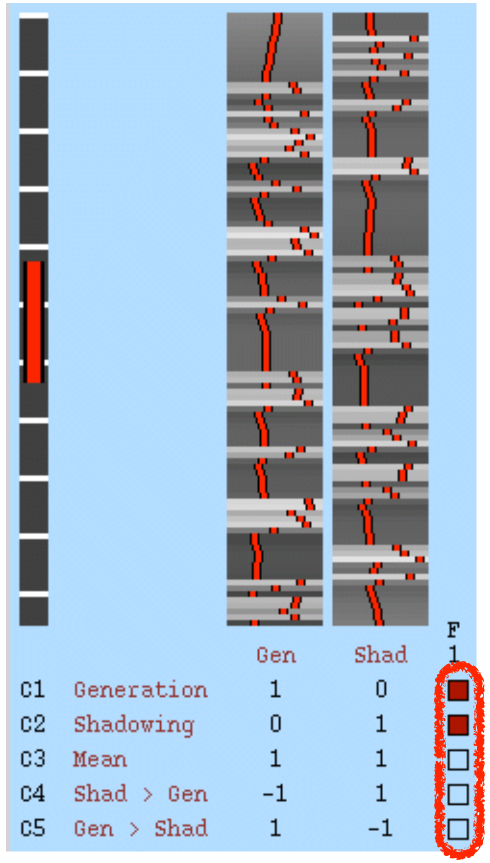
  在各种条件下是否有激活?

  - Does any regressor explain variance in the data?

  有回归能解释这些数据中的变异吗?

- F-contrasts are not directional

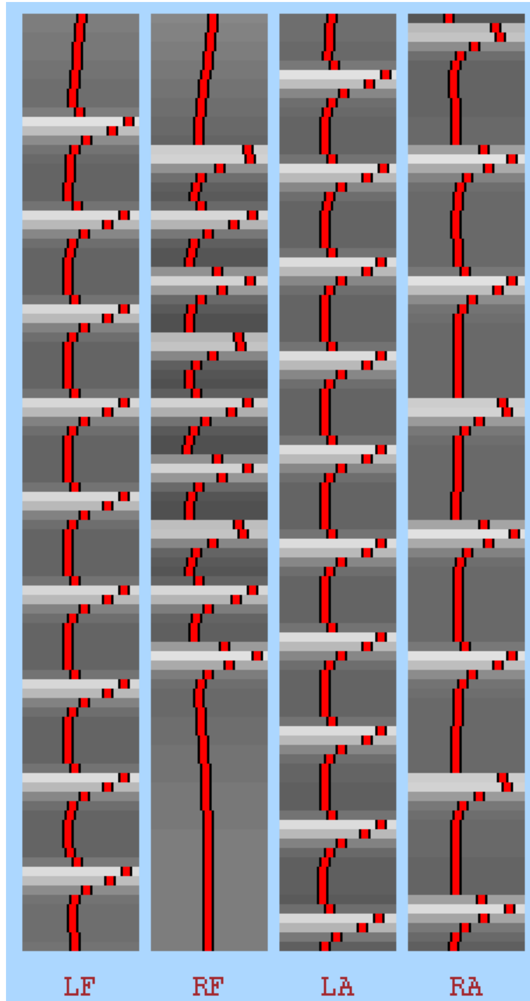
F对比不是方向性的



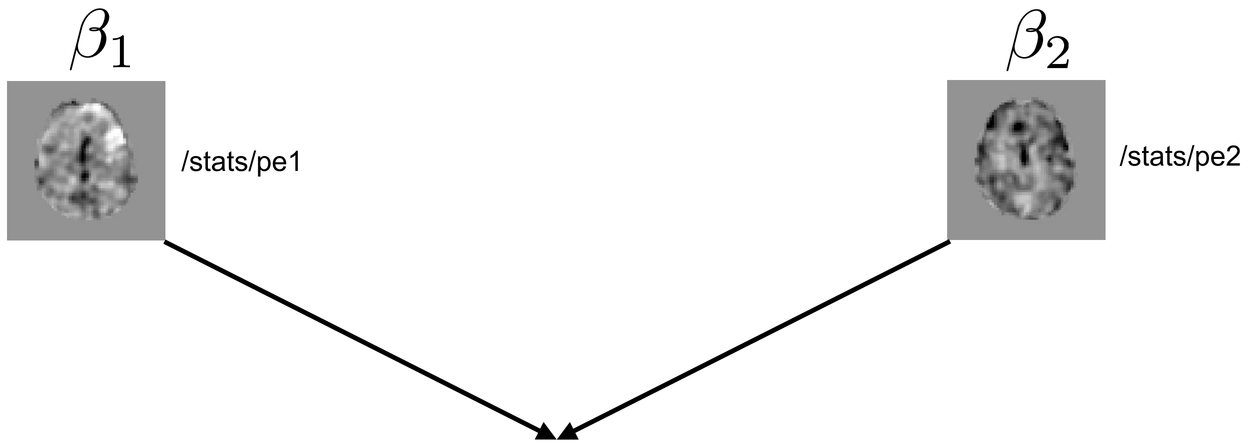
Let’s think!
思考一下！

In your pain study, what contrasts would you set to ask the following questions:
在你的疼痛研究中，为了回答下面的问题你会怎么设置对比：

1. Which brain regions activate more to pinpricks to the left than the right foot? 相比右脚的针刺刺激，左脚的针刺刺激更能激活大脑的哪个区域?
2. Which brain regions activate in response to pinpricks to the left or right foot? 左脚或者右脚的针刺刺激会激活大脑的哪个区域?



Research questions 研究问题



Which areas of the brain are significantly activated during word generation compared to baseline?

与基线相比，词生成过程中大脑的哪些区域被显著激活?

Which areas of the brain are significantly more activated during word generation compared to word shadowing?

与词遮档相比，词生成过程中大脑的哪些区域的激活明显更多?

Next time 下次

1. Data acquisition 数据采集

2. Data preprocessing 数据预处理

3. Single-subject analysis 单被试分析

4. Group-level analysis 组分析

5. Statistical inference 统计推断

The free online appendix 免费网上的教材

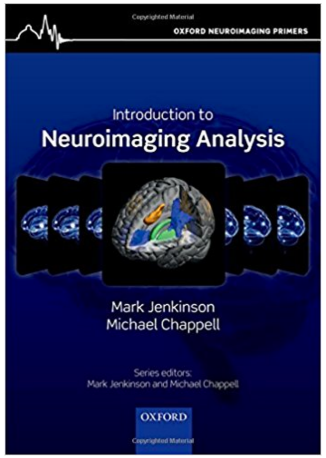
- Part of a series of Oxford Neuroimaging Primers

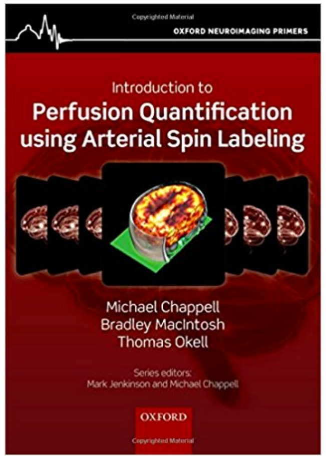
  牛津影像入门系列的一部分

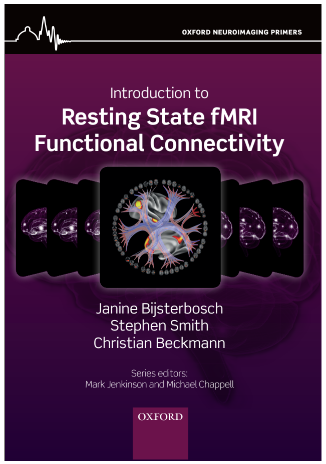
- https://www.fmrib.ox.ac.uk/primers/appendices/glm.pdf

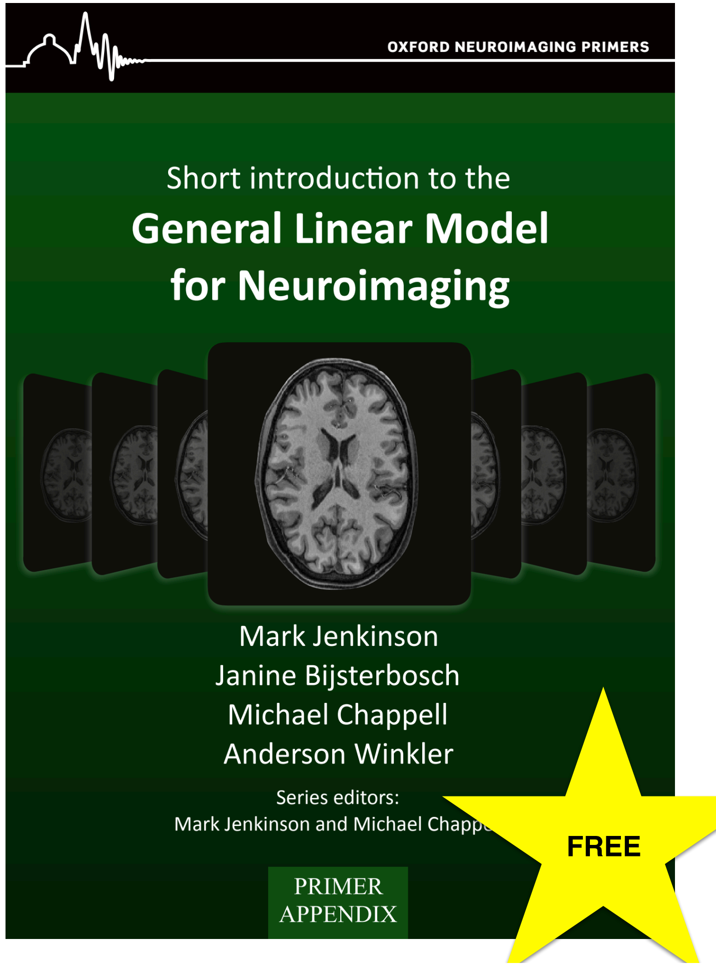
- Work on a full primer book on the GLM is in progress!

  有关GLM的完整入门书籍的工作正在进行中!









That’s all folks