Advanced designs

Advanced Analysis:
Parametric Designs

Scenario:

    Interested in specific responses to multiple levels of a painful stimulus

Specific questions:

    Are there regions showing significant responses to painful stimuli?

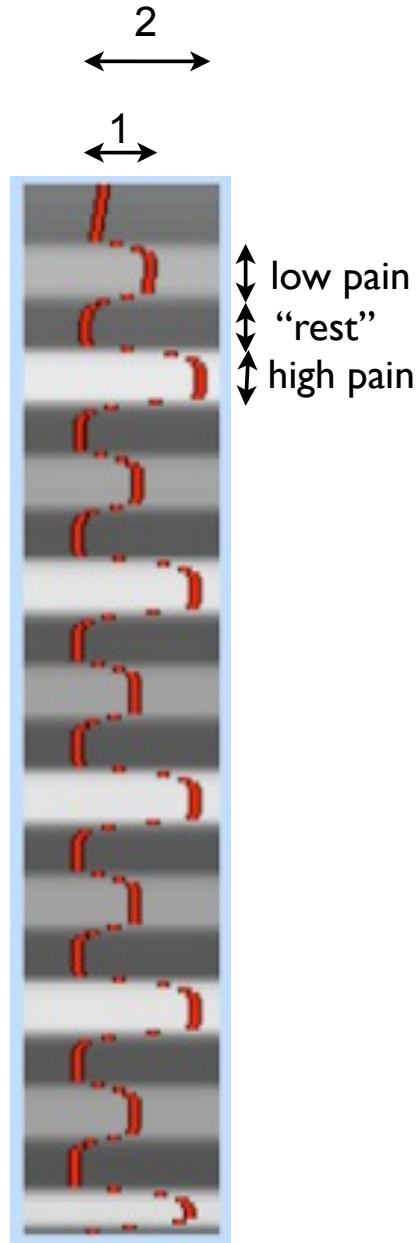   Are there regions where higher intensity stimuli produce larger responses?

    Are there regions with a linear response across multiple levels of stimuli?

Solution:

    Multiple regressors

    Contrasts and F-tests

Analysis of responses to multiple levels of painful stimuli: modelling
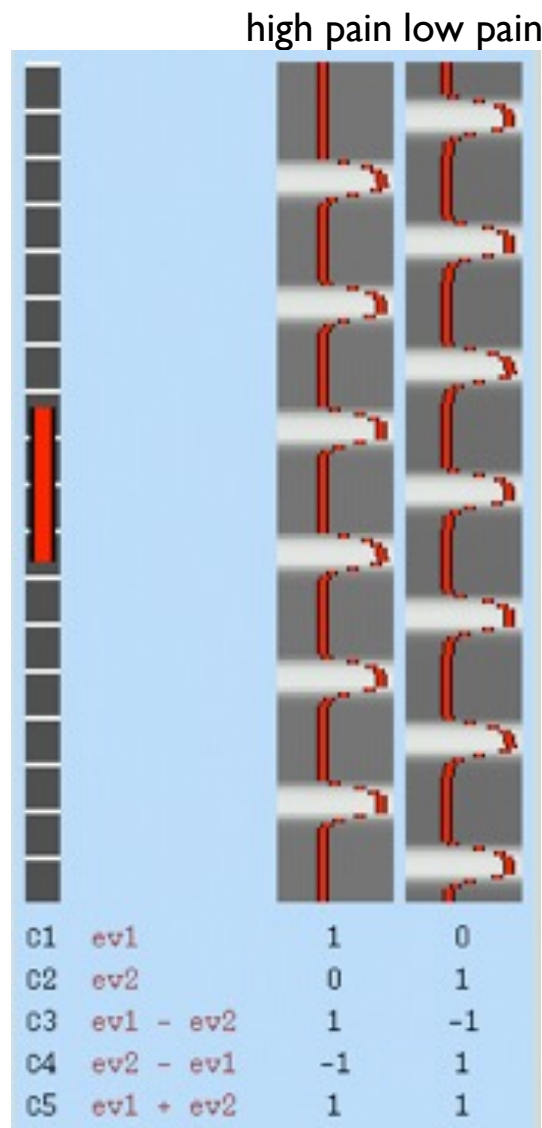

low pain
"rest"
high pain

- Possible approach: model a specific hypothesis - high produces twice the response as low

- Pre-supposes relationship between stimulation strength and response

- Can only ask the question about the pre-supposed relationship

Analysis of responses to multiple levels of painful stimuli: modelling
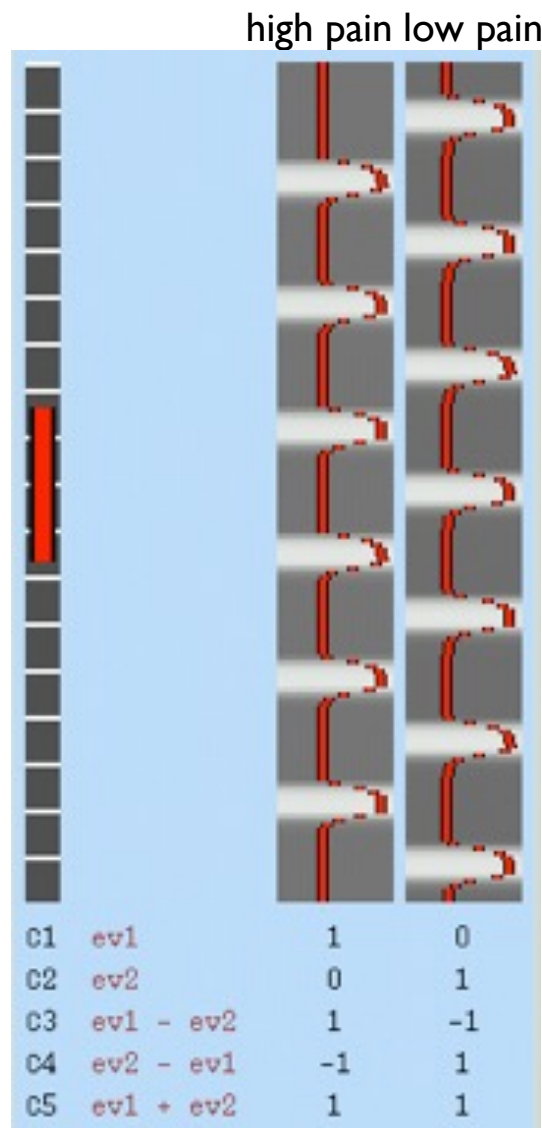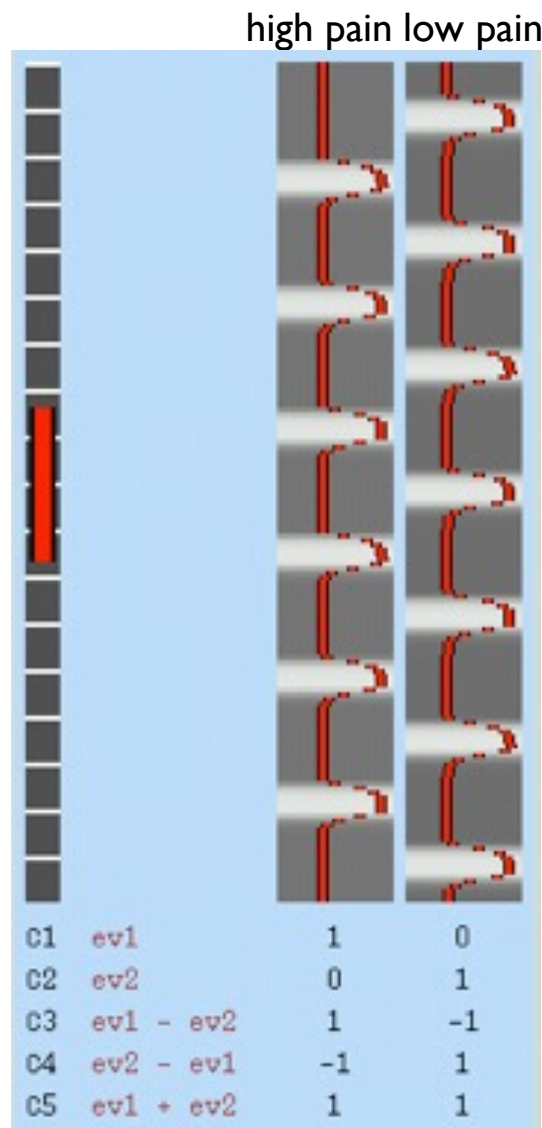
high pain low pain

- • Better approach: model as if two completely different stimuli
- • Now, no pre-supposition about relationship between stimulation strength and response

- • Can assess responses to individual stimuli

  - • t-contrast [0 1]:" response to low pain"

C1	ev1	1	0
C2	ev2	0	1
C3	ev1 - ev2	1	-1
C4	ev2 - ev1	-1	1
C5	ev1 + ev2	1	1

Analysis of responses to multiple levels of painful stimuli: modelling

high pain low pain

C1	ev1	1	0
C2	ev2	0	1
C3	ev1 - ev2	1	-1
C4	ev2 - ev1	-1	1
C5	ev1 + ev2	1	1

- Better approach: model as if two completely different stimuli
- Now, no pre-supposition about relationship between stimulation strength and response

- Can compare the size of the fits of the two regressors -

  - t-contrast [1 -1] : "is the response to high pain greater than that to low pain ?"

  - t-contrast [-1 1] : "is the response to low pain greater than that to high pain ?"

Analysis of responses to multiple levels of painful stimuli: modelling

high pain low pain

C1	ev1	1	0
C2	ev2	0	1
C3	ev1 - ev2	1	-1
C4	ev2 - ev1	-1	1
C5	ev1 + ev2	1	1

- Better approach: model as if two completely different stimuli
- Now, no pre-supposition about relationship between stimulation strength and response

- Average response?
  - t-contrast [1 1] : "is the average response to pain greater than zero?"

Parametric Variation:
Linear Trends

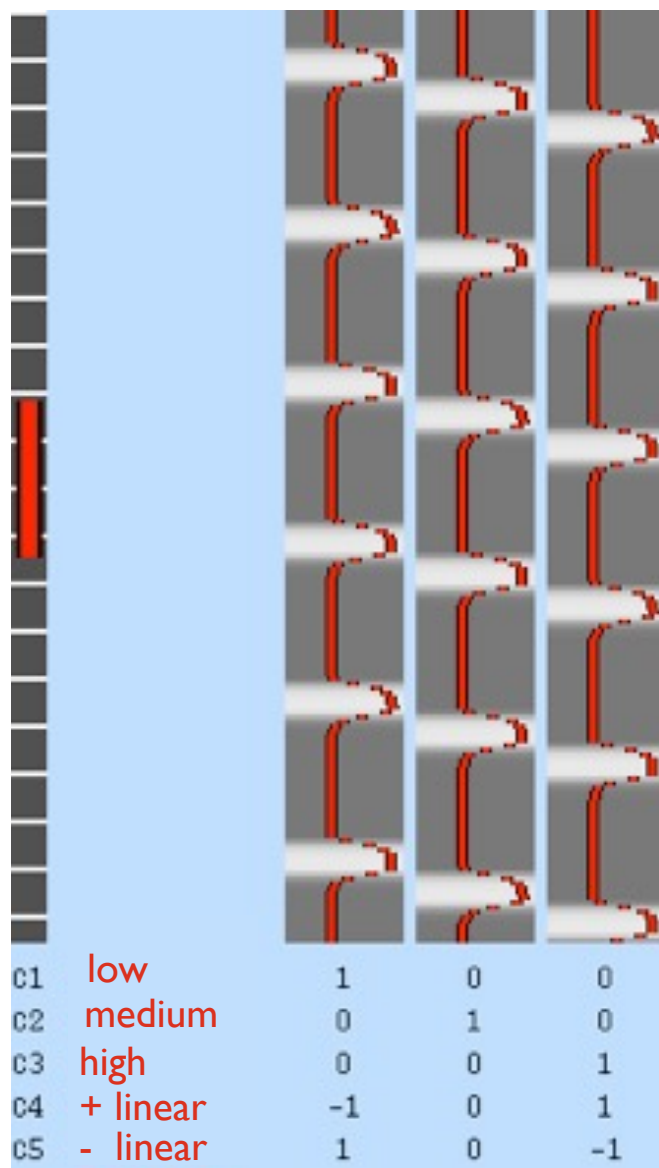- Is there a linear trend between the BOLD response and stimulus intensity?

Parametric Variation: Linear Trends

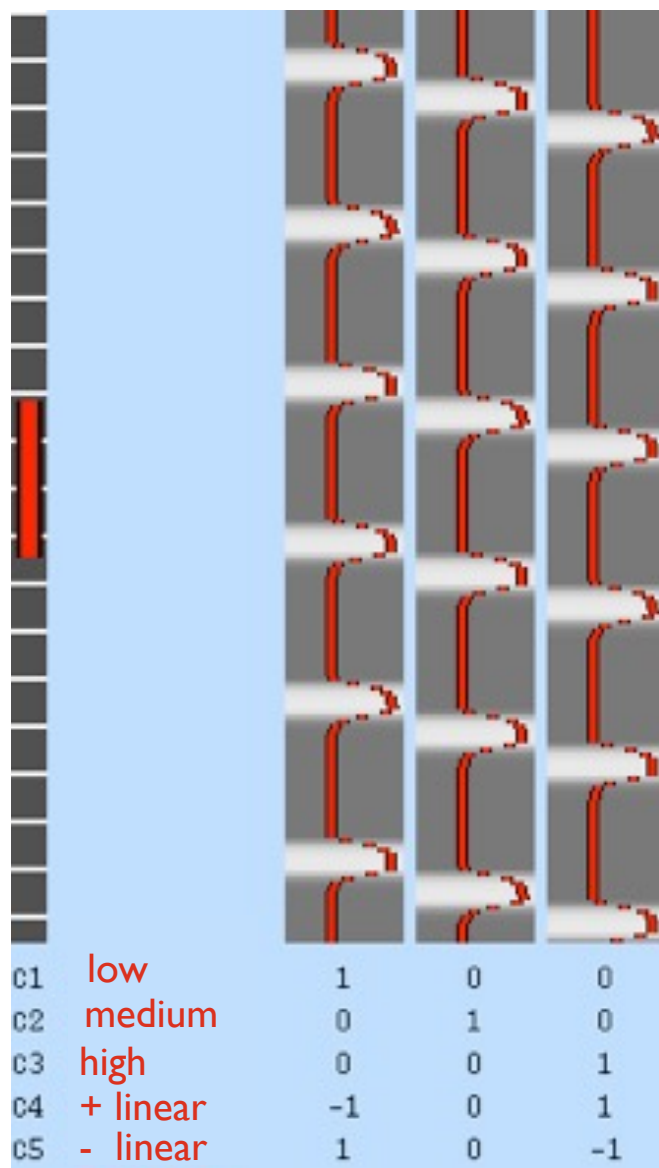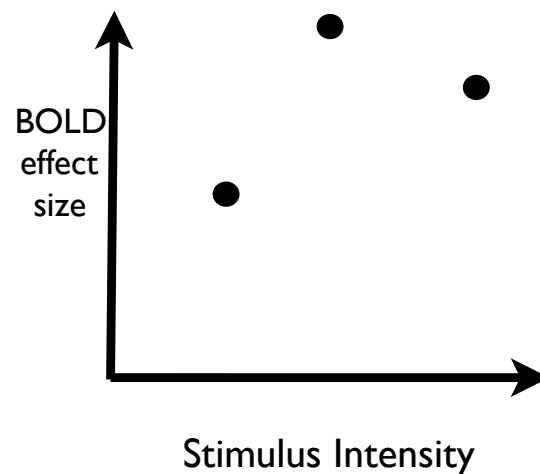- Is there a linear trend between the BOLD response and stimulus intensity?

Parametric Variation:
Linear Trends

		1	0	0
c1	low	1	0	0
c2	medium	0	1	0
c3	high	0	0	1
c4	+ linear	-1	0	1
c5	- linear	1	0	-1

- A three-strength experiment

- Is there a linear trend between the BOLD response and some task variable?
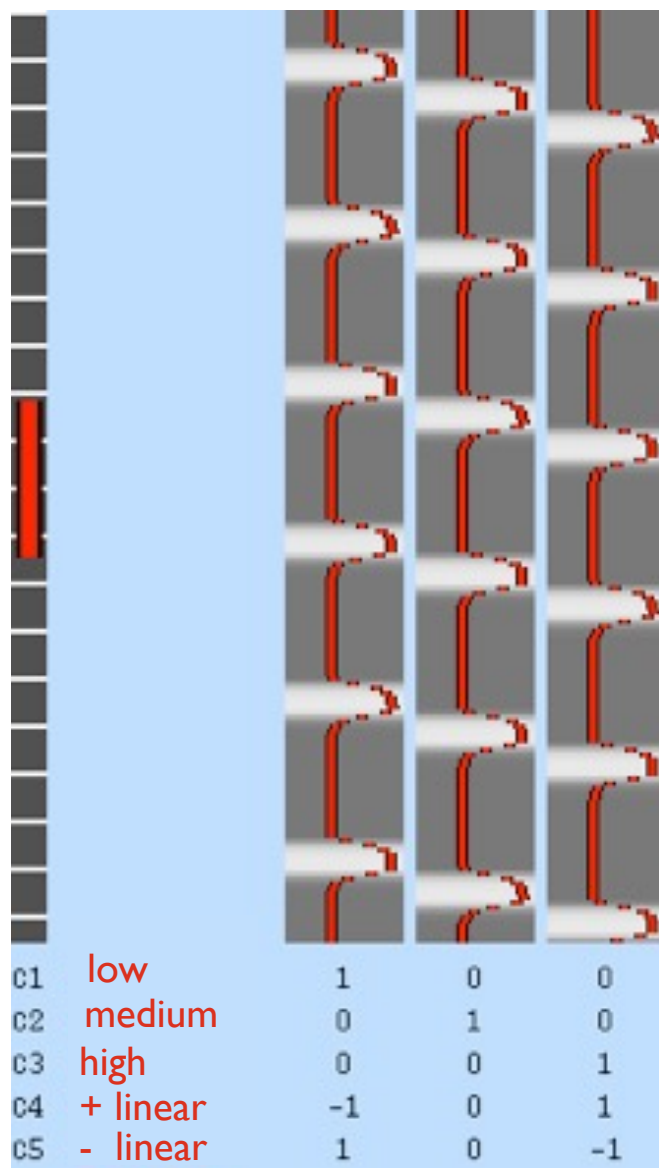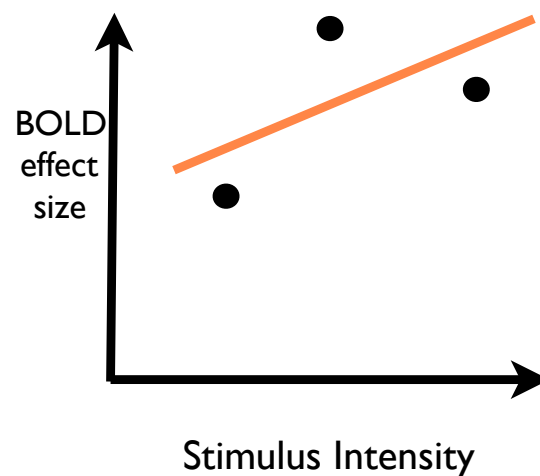
- t-contrast [-1 0 1] : Linear trend
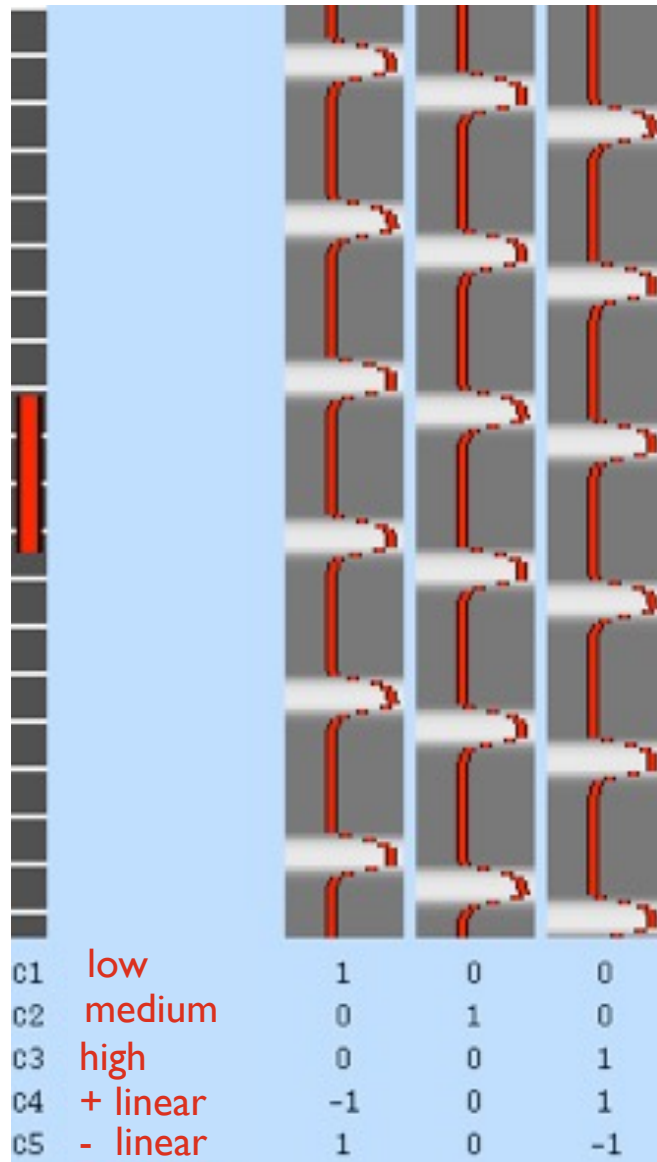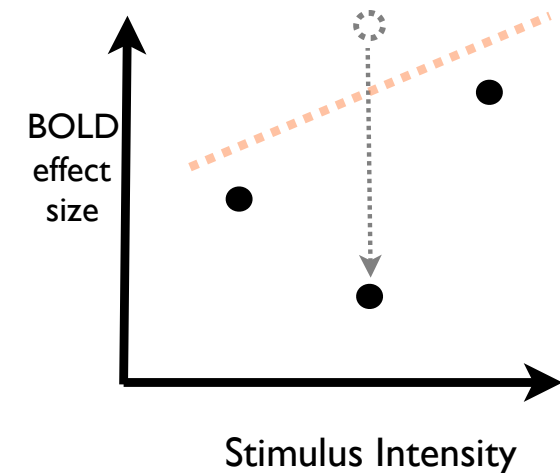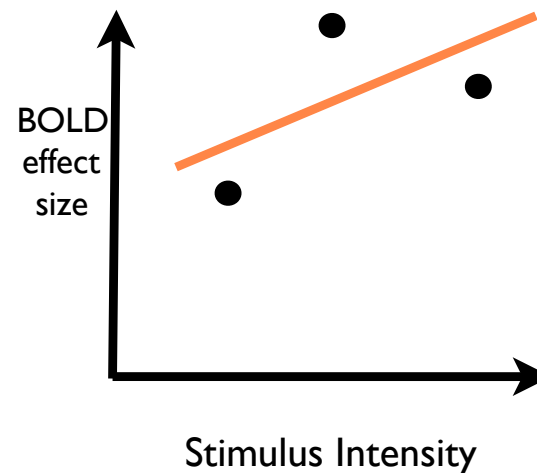
Parametric Variation: Linear Trends

C1	low	1	0	0
C2	medium	0	1	0
C3	high	0	0	1
C4	+ linear	-1	0	1
C5	- linear	1	0	-1

- A three-strength experiment

- Is there a linear trend between the BOLD response and some task variable?
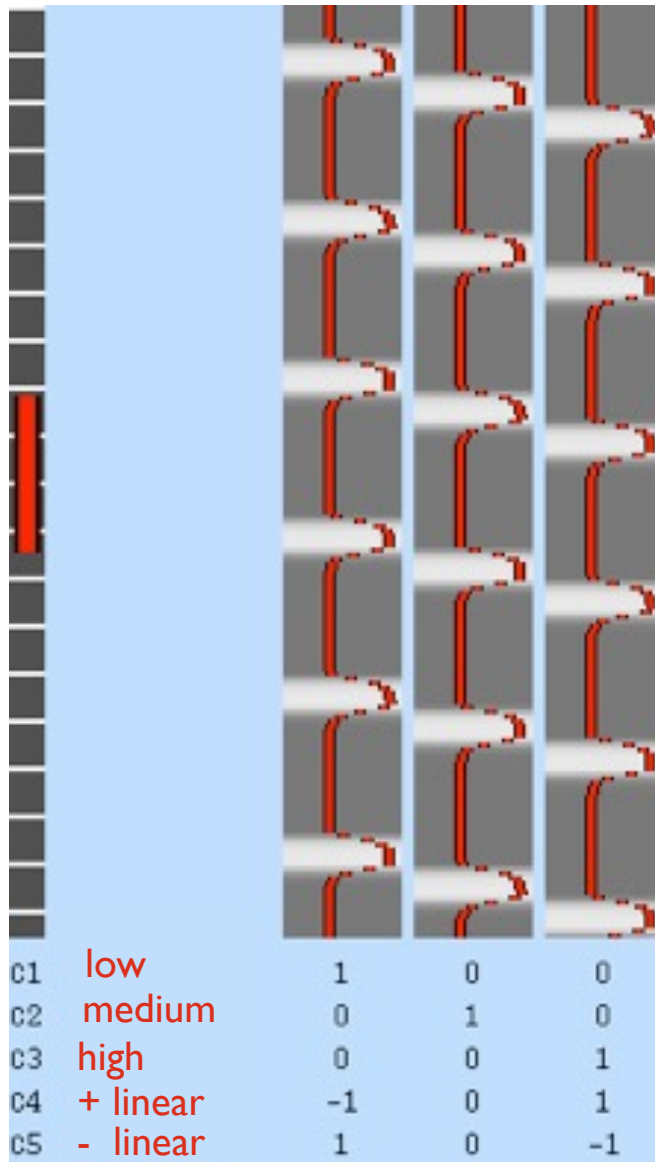
- t-contrast [-1 0 1] : Linear trend

BOLD effect size

Stimulus Intensity

Parametric Variation: Linear Trends

c1	low	1	0	0
c2	medium	0	1	0
c3	high	0	0	1
c4	+ linear	-1	0	1
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- A three-strength experiment

- Is there a linear trend between the BOLD response and some task variable?

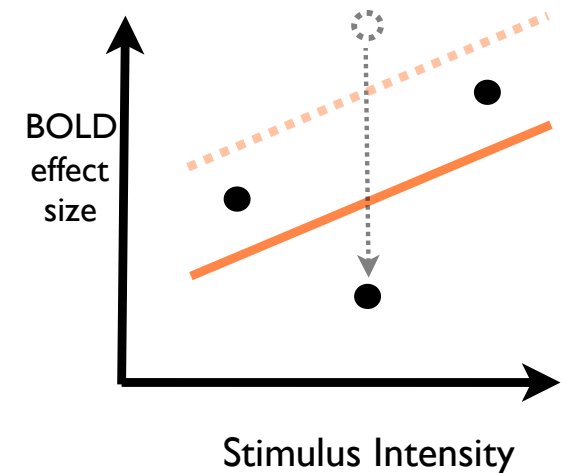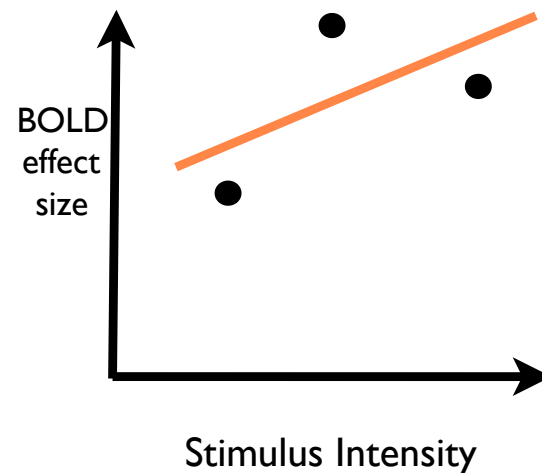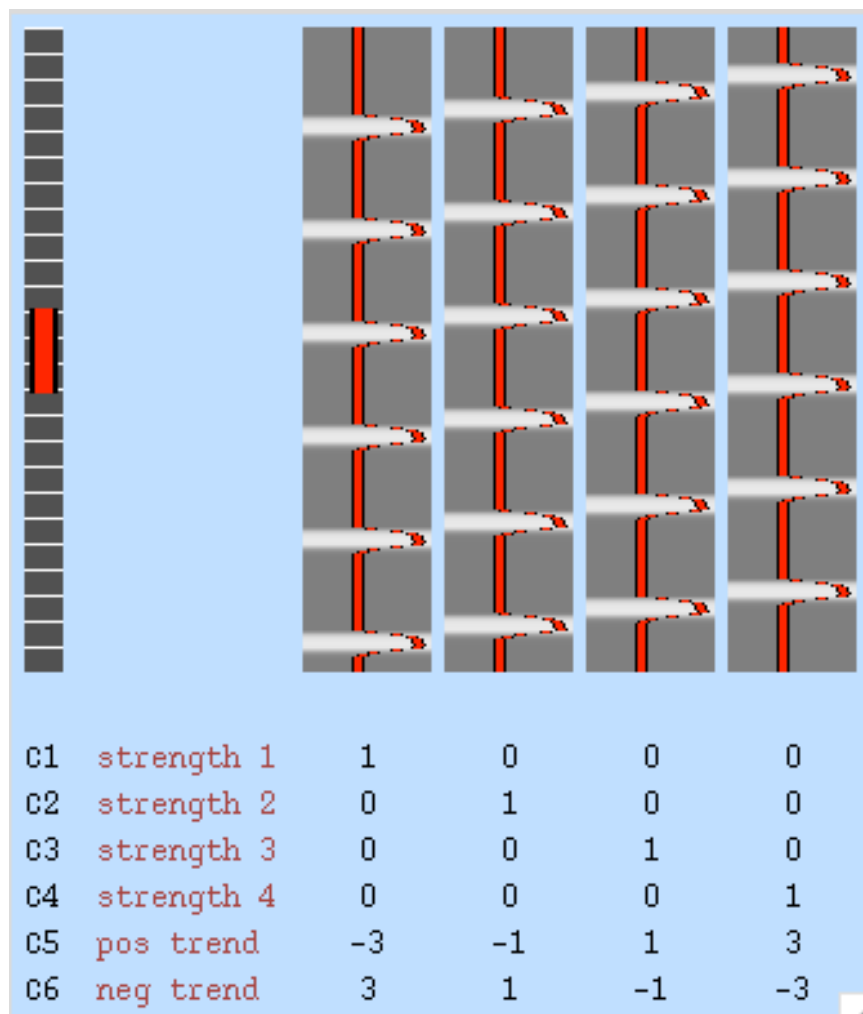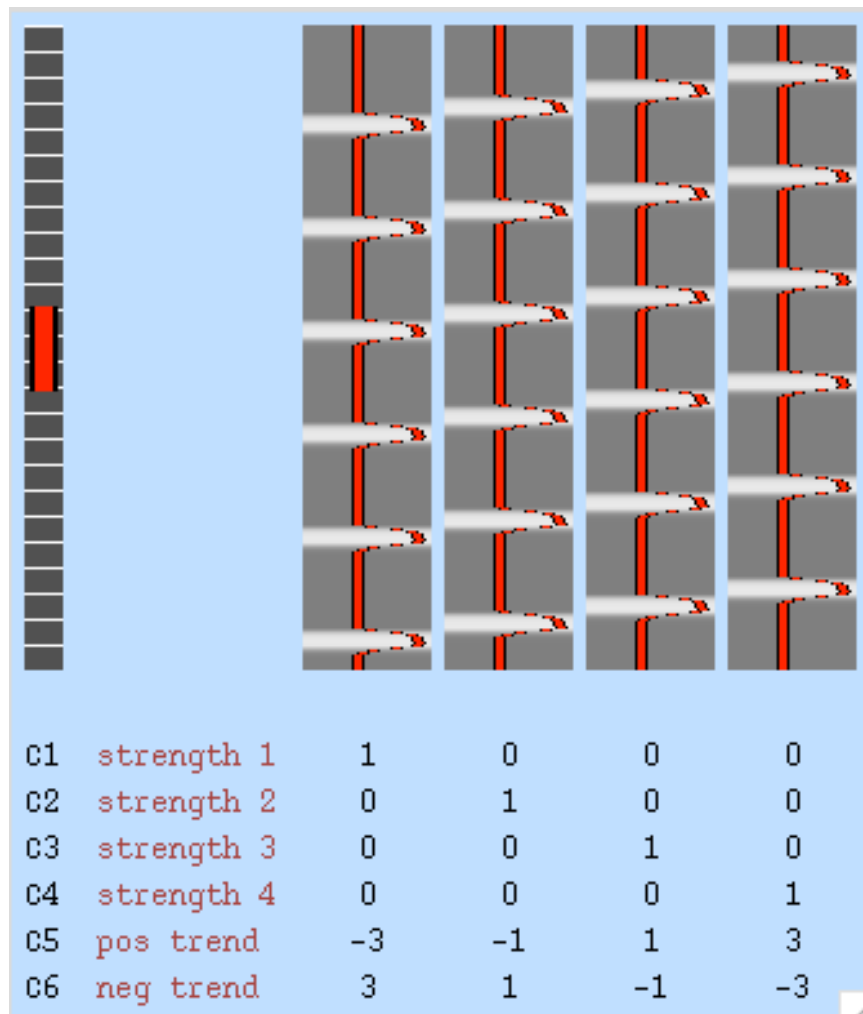- t-contrast [-1 0 1] : Linear trend

Parametric Variation: Linear Trends

C1	low	1	0	0
C2	medium	0	1	0
C3	high	0	0	1
C4	+ linear	-1	0	1
C5	- linear	1	0	-1

- A three-strength experiment

- Is there a linear trend between the BOLD response and some task variable?

- t-contrast [-1 0 1] : Linear trend

BOLD effect size — Stimulus Intensity

BOLD effect size — Stimulus Intensity

Slope ($\beta_3 - \beta_1$) is the same for both

Parametric Variation: Linear Trends
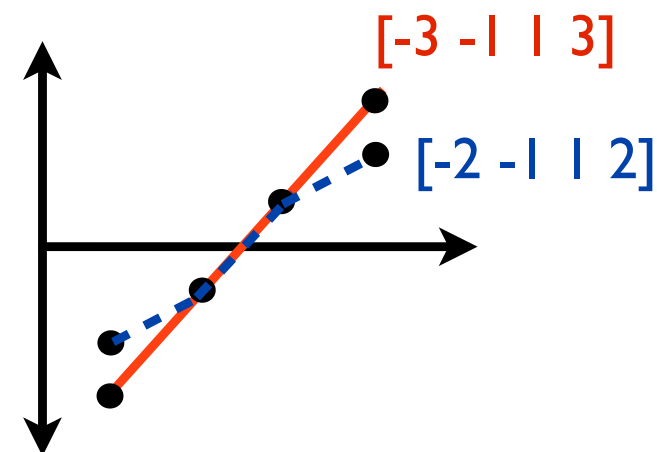

- A four-strength experiment

- t-contrast [-3 -1 1 3] : Positive linear trend

Parametric Variation: Linear Trends
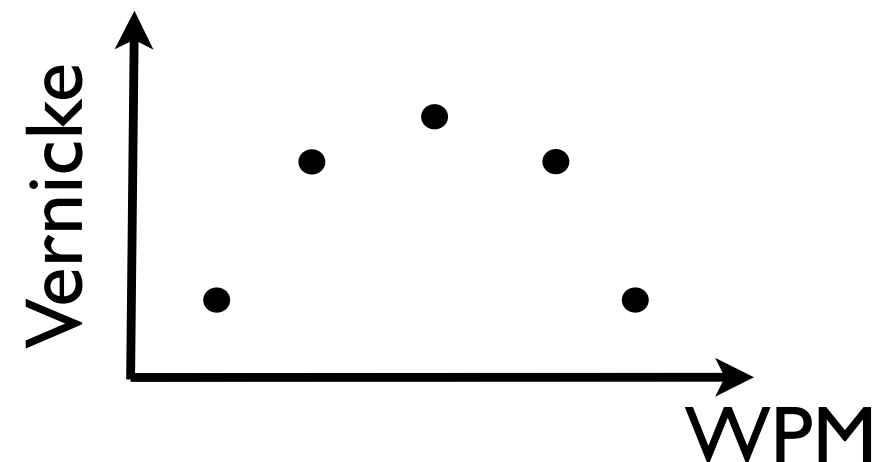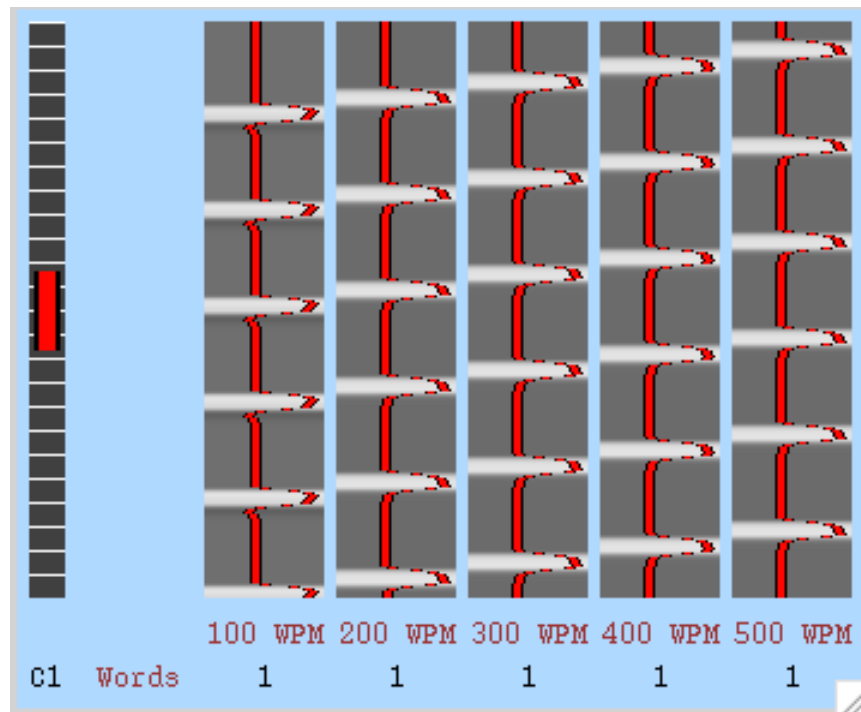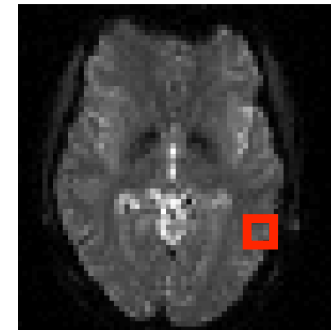

C1	strength 1	1	0	0	0
C2	strength 2	0	1	0	0
C3	strength 3	0	0	1	0
C4	strength 4	0	0	0	1
C5	pos trend	-3	-1	1	3
C6	neg trend	3	1	-1	-3

- A four-strength experiment

- t-contrast [-3 -1 1 3] : Positive linear trend

[-3 -1 1 3]

[-2 -1 1 2]

But what if it isn't that predictable?

Auditory word presentation
at different rates

100 WPM 200 WPM 300 WPM 400 WPM 500 WPM

C1 Words   1   1   1   1   1

True story

But what if it isn't that predictable?

Given this design what would be "reasonable" questions to ask?

		100 WPM	200 WPM	300 WPM	400 WPM	500 WPM
C1	Words	1	1	1	1	1
C2	500>100	-1	0	0	0	1
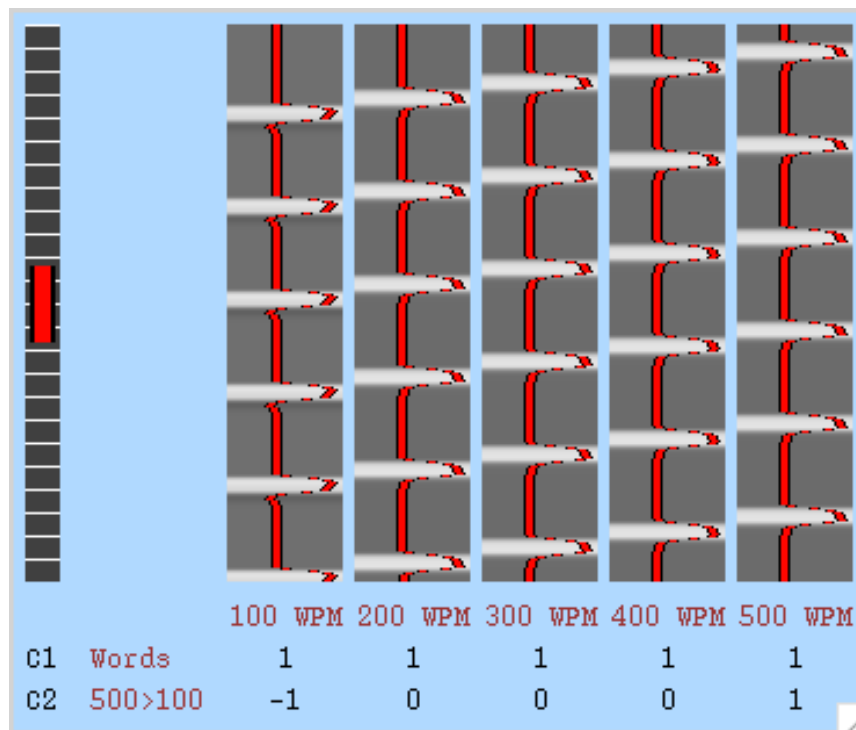
More activation to 500 than to 100 WPM?
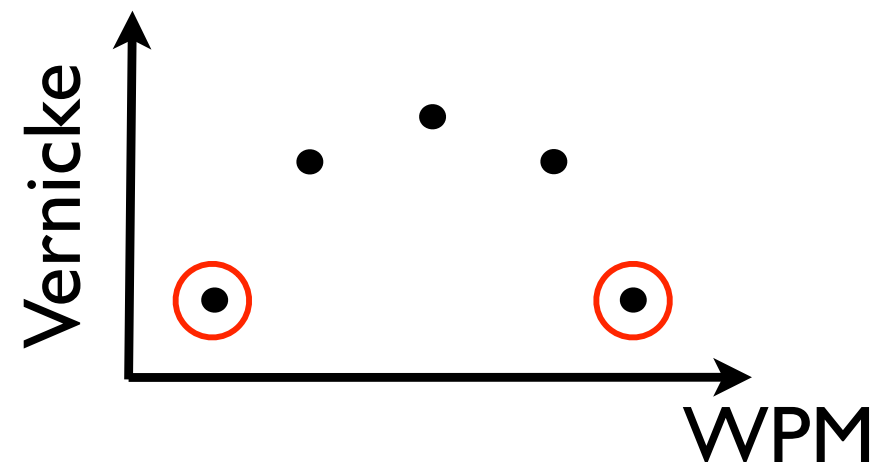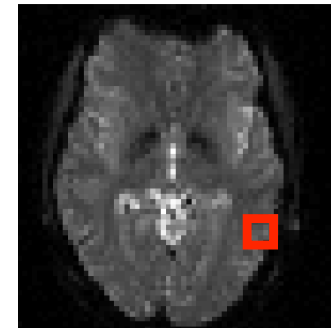
But no...

True story

But what if it isn't that predictable?

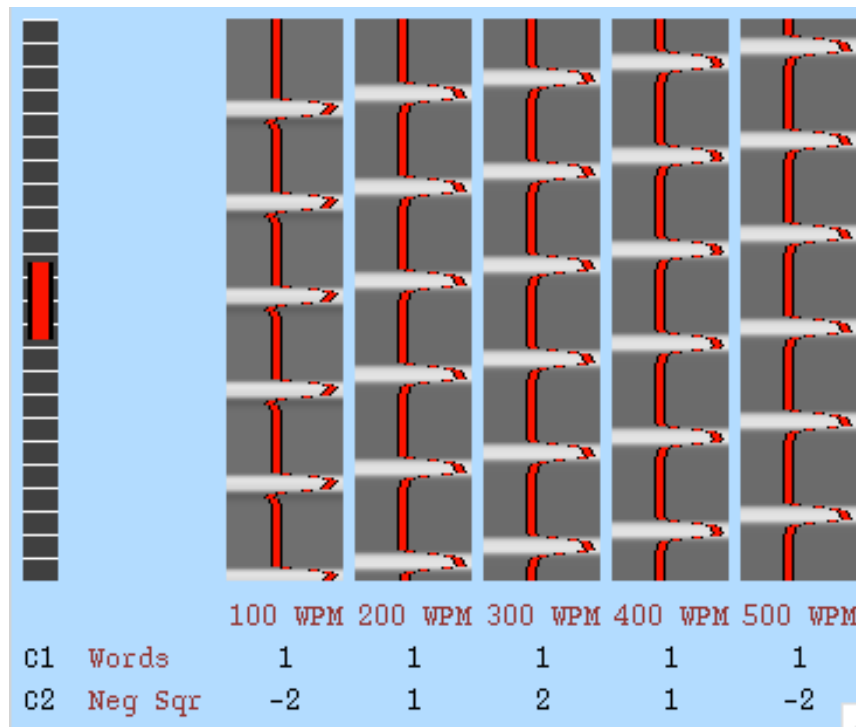Given this design what would be "reasonable" questions to ask?

		100 WPM	200 WPM	300 WPM	400 WPM	500 WPM
C1	Words	1	1	1	1	1
C2	Linear	-2	-1	0	1	2
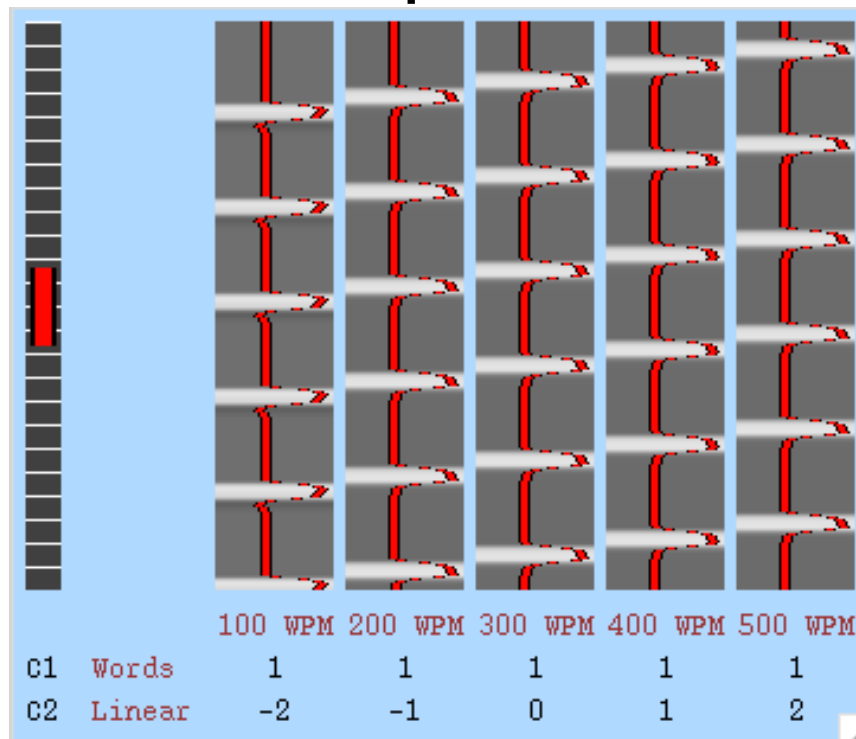
Activation proportional to WPM?
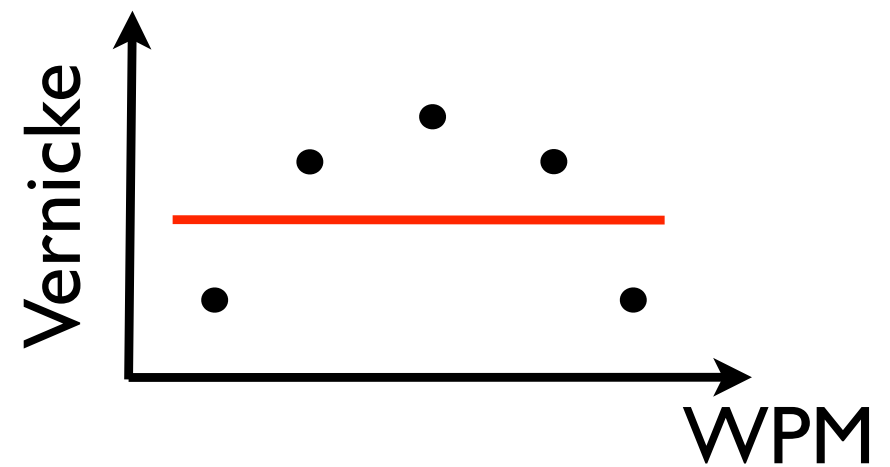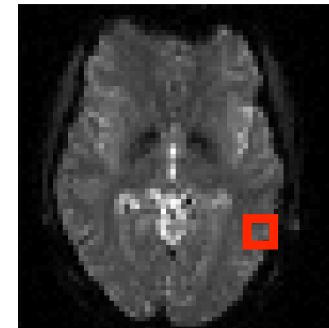
Vernicke

WPM

Still no...

True story

But what if it isn't that predictable?

Given this design what would be "reasonable" questions to ask?

		100 WPM	200 WPM	300 WPM	400 WPM	500 WPM
C1	Words	1	1	1	1	1
C2	Neg Sqr	-2	1	2	1	-2

Inversely proportional to WPM squared?

Yaay!

True story

But what if it isn't that predictable?

Given this design what would be "reasonable" questions to ask?

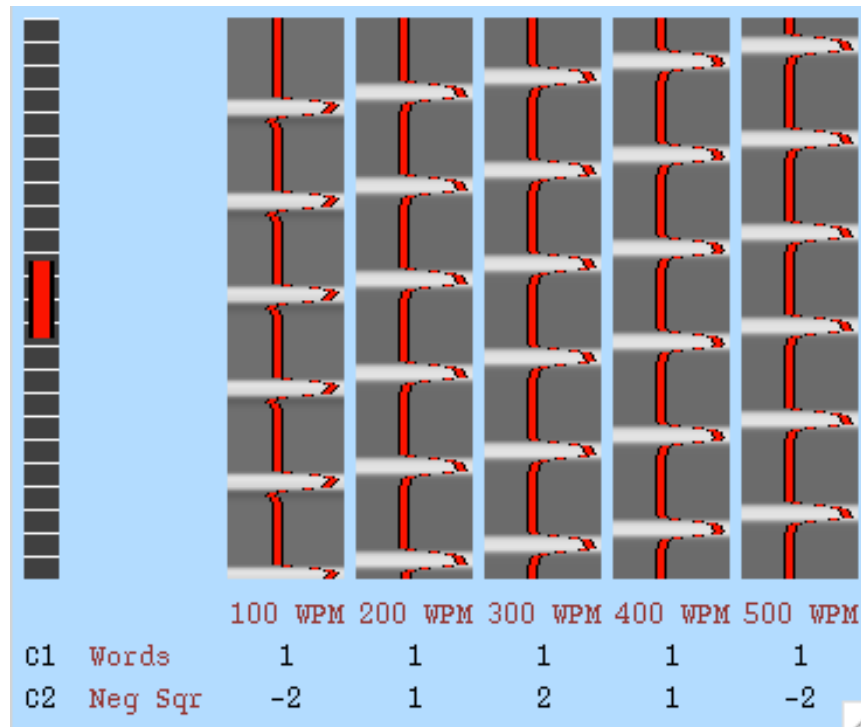|		100 WPM	200 WPM	300 WPM	400 WPM	500 WPM
C1	Words	1	1	1	1	1
C2	Neg Sqr	-2	1	2	1	-2
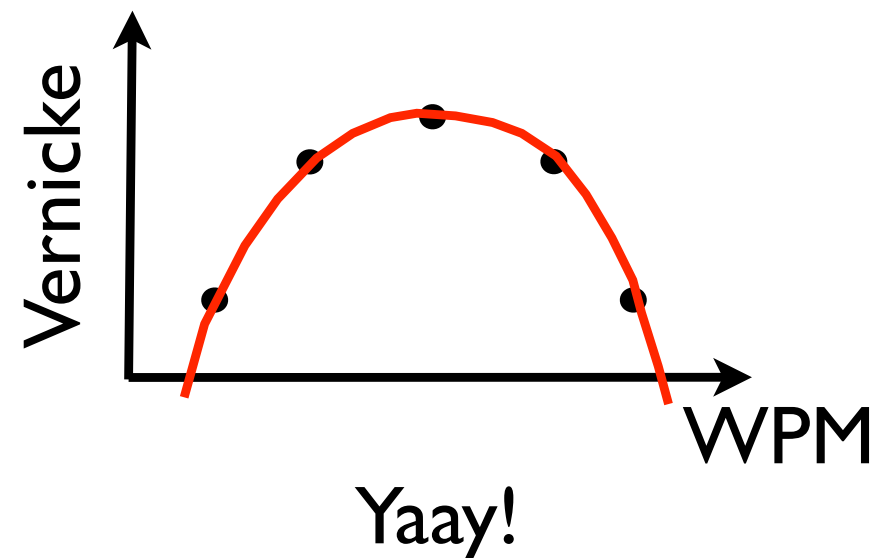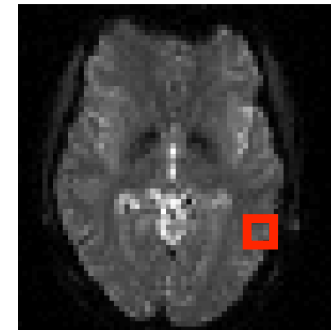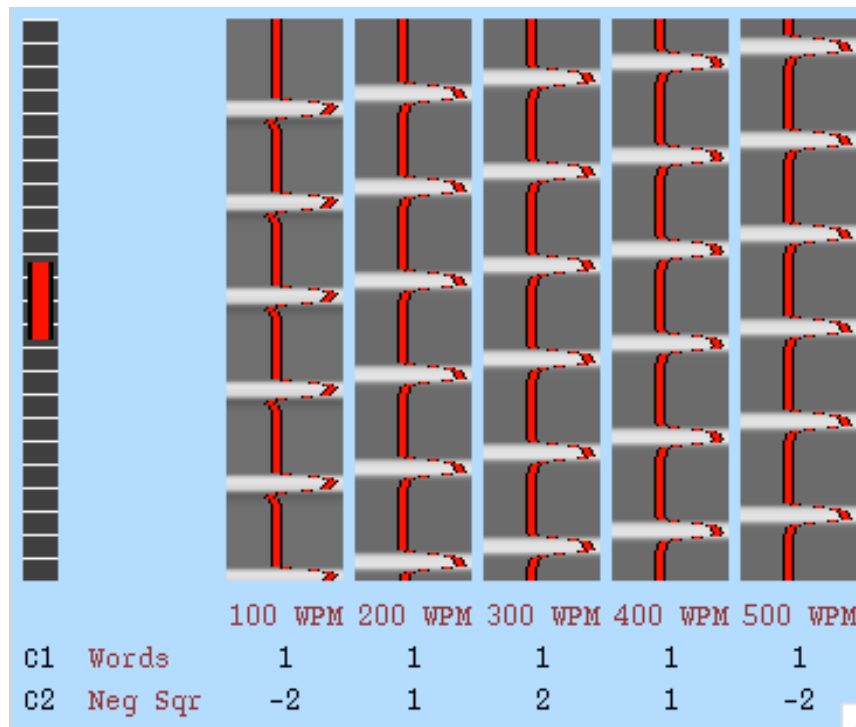
Inversely proportional to WPM squared?
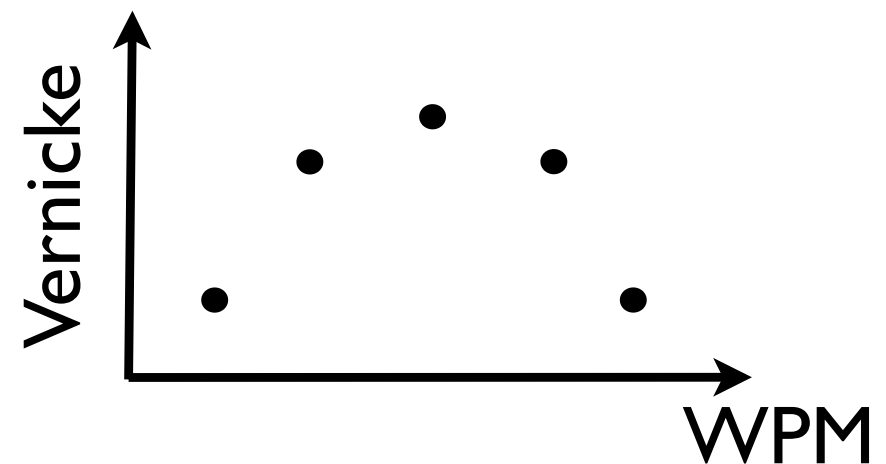
But seriously … would you have asked that question?

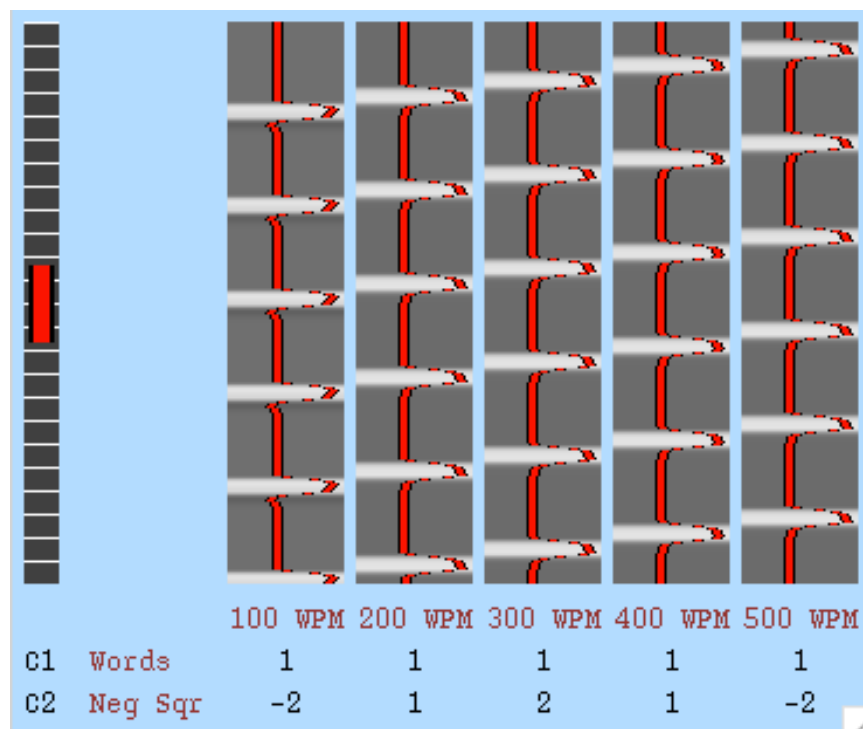Yaay!
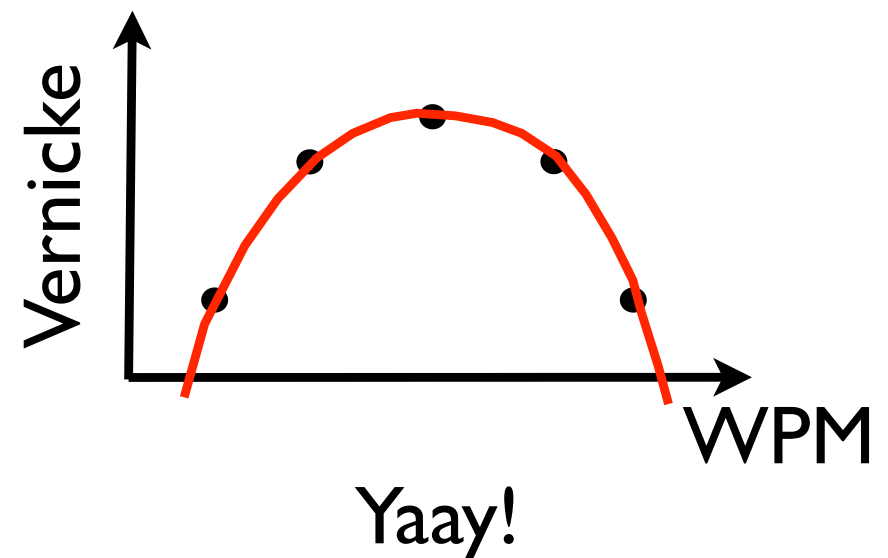
True story

But what if it isn't that predictable?

There is a (very real) risk of missing interesting but unpredicted responses

		100 WPM	200 WPM	300 WPM	400 WPM	500 WPM
C1	Words	1	1	1	1	1
C2	Neg Sqr	-2	1	2	1	-2

What can we do about that?

Vernicke / WPM

F-contrasts to the rescue

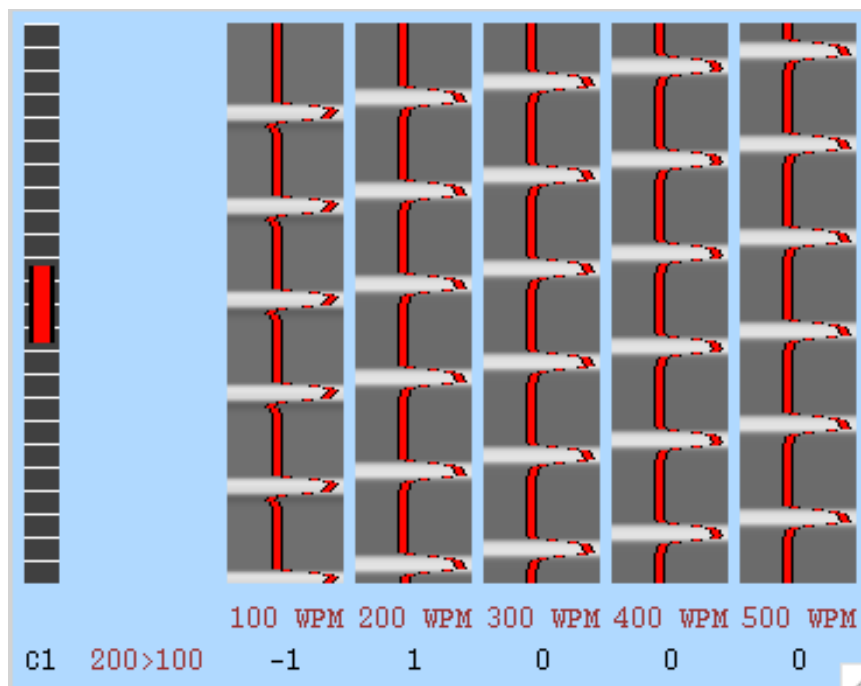|		100 WPM	200 WPM	300 WPM	400 WPM	500 WPM
C1	Words	1	1	1	1	1
C2	Neg Sqr	-2	1	2	1	-2

We can define an F-contrast that spans "the range of possible responses"

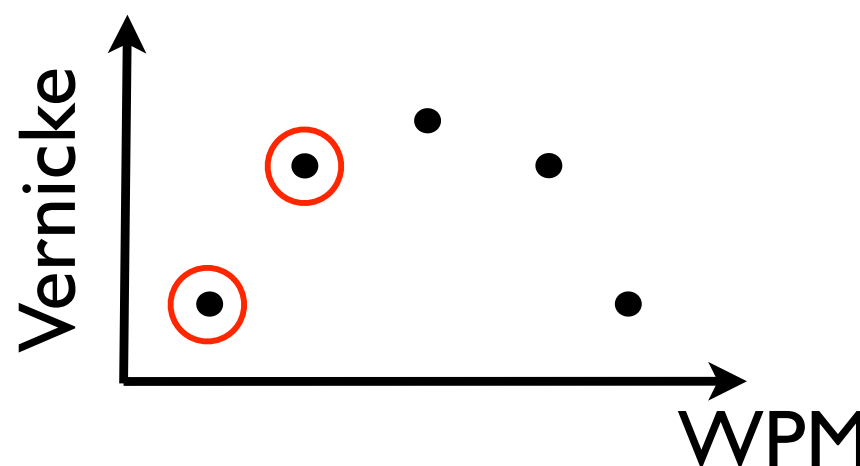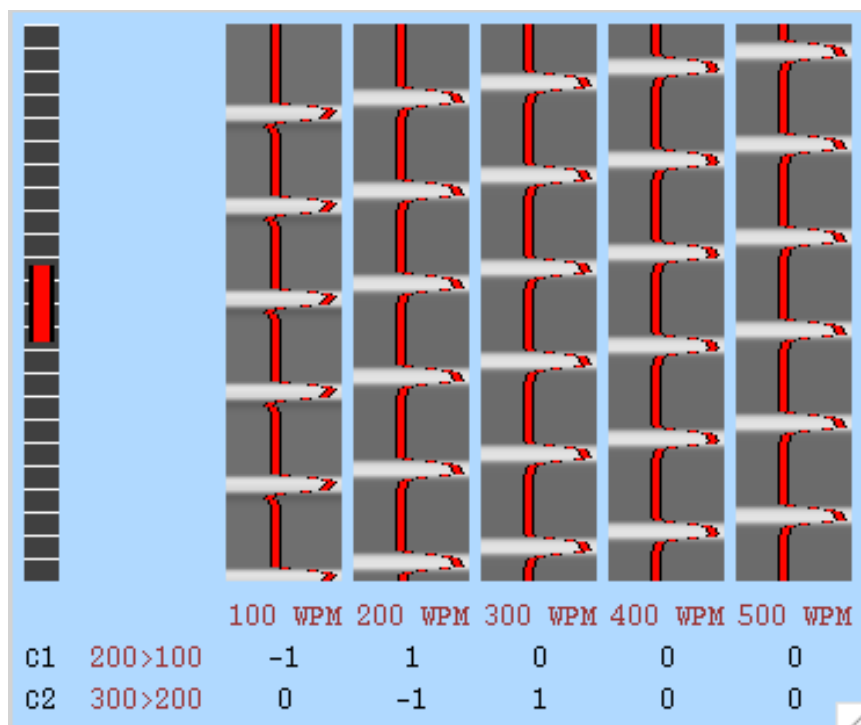An F-contrast is a series of questions (*t*-contrasts) with an OR between them

True story

F-contrasts to the rescue

We can define an F-contrast that spans "the range of possible responses"
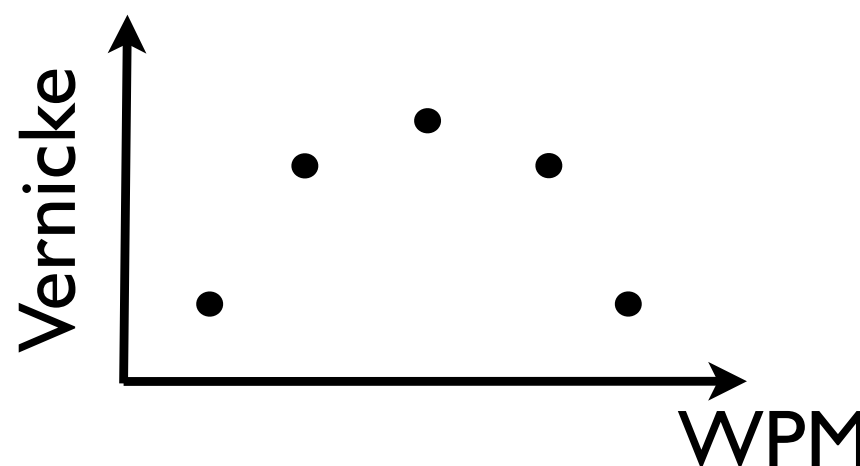
Let's start with "Greater activation to 200 than 100 WPM

True story

F-contrasts to the rescue

		100 WPM	200 WPM	300 WPM	400 WPM	500 WPM
C1	200>100	-1	1	0	0	0
C2	300>200	0	-1	1	0	0

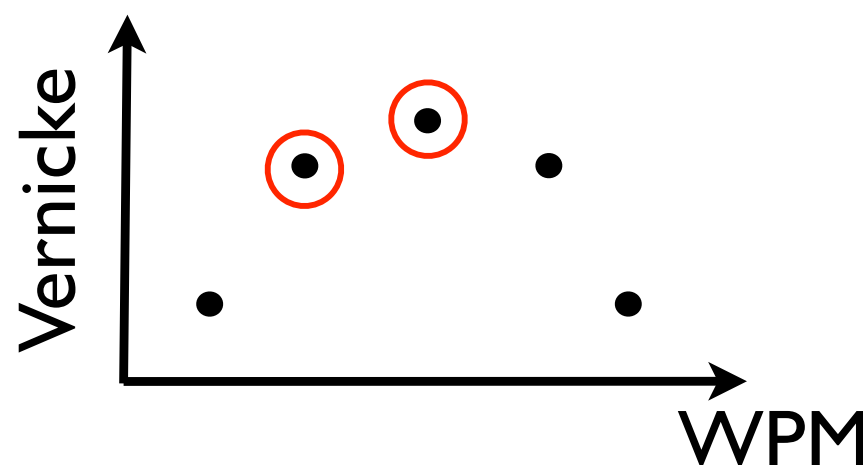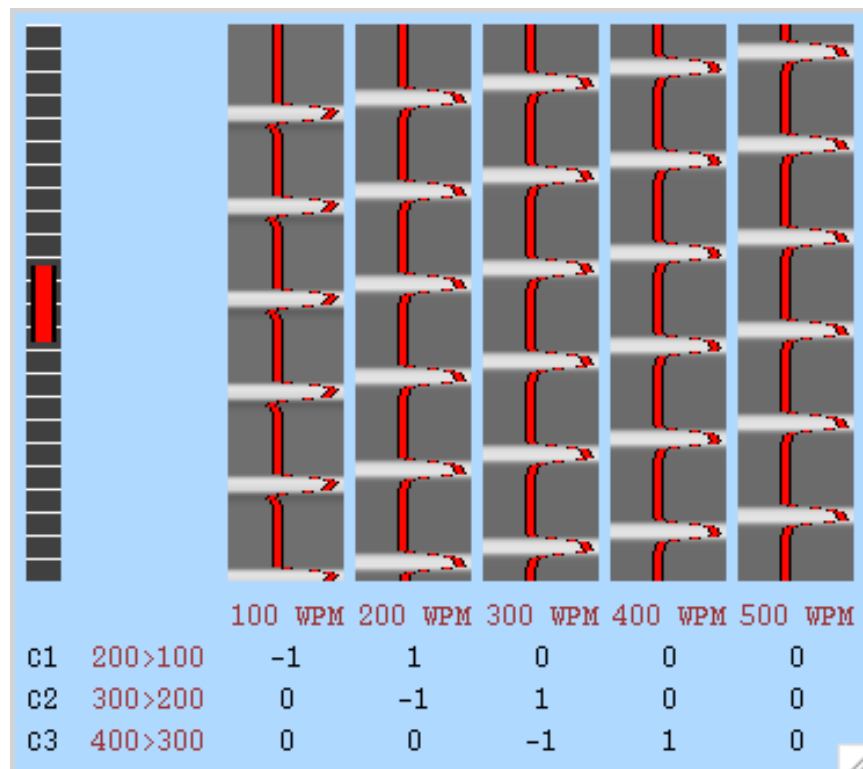**OR**

300WPM > 200WPM

We can define an F-contrast that spans "the range of possible responses"

F-contrasts to the rescue

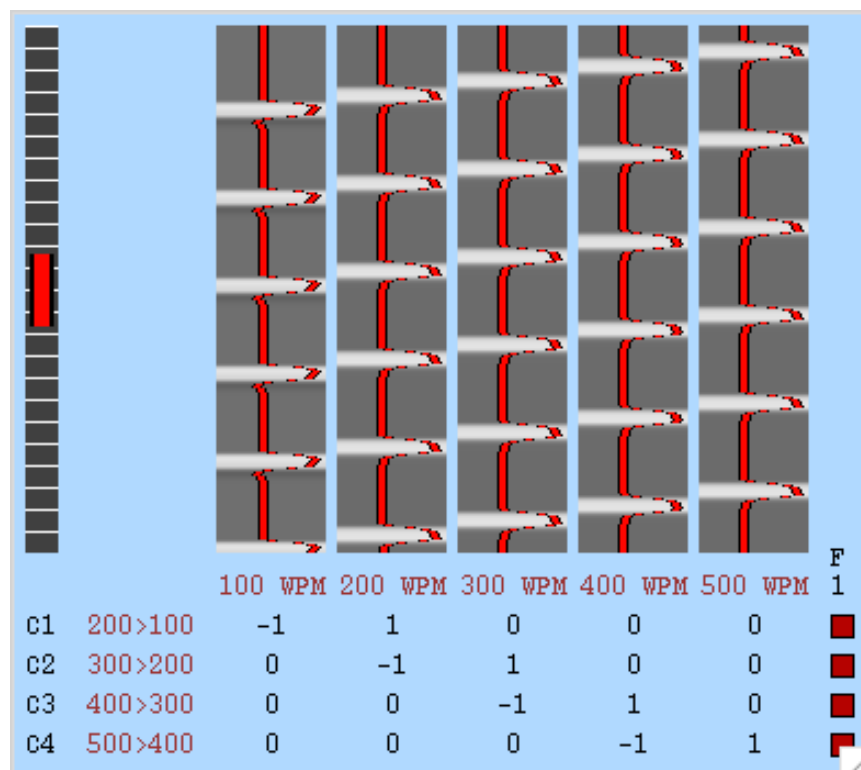|		100 WPM	200 WPM	300 WPM	400 WPM	500 WPM
c1	200>100	-1	1	0	0	0
c2	300>200	0	-1	1	0	0
c3	400>300	0	0	-1	1	0

OR

400WPM > 300WPM

We can define an F-contrast that spans "the range of possible responses"
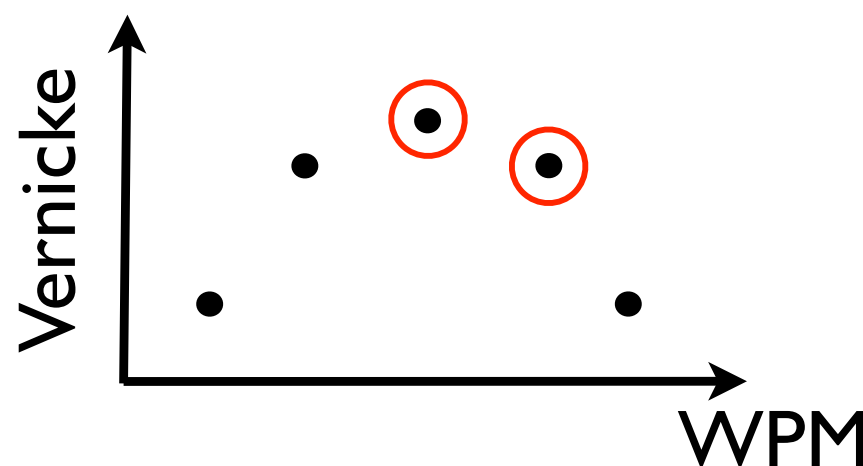
True story

F-contrasts to the rescue

F-contrasts to the rescue

		100 WPM	200 WPM	300 WPM	400 WPM	500 WPM	F 1
c1	200>100	-1	1	0	0	0	
c2	300>200	0	-1	1	0	0	
c3	400>300	0	0	-1	1	0	
c4	500>400	0	0	0	-1	1	
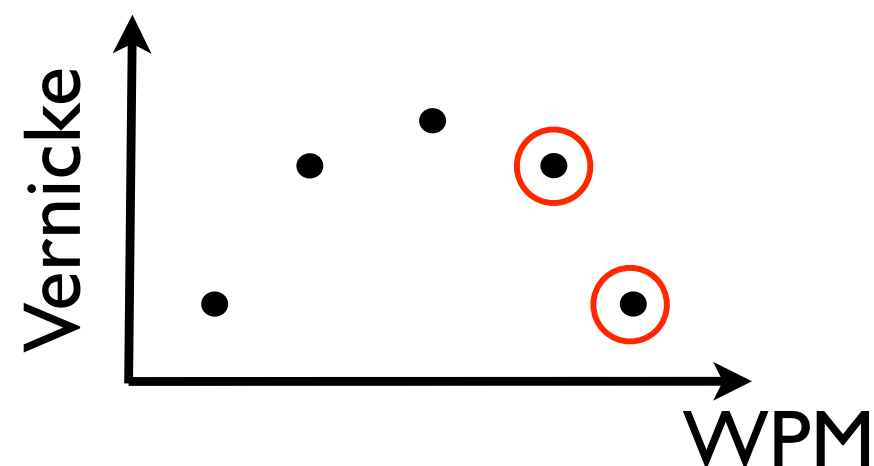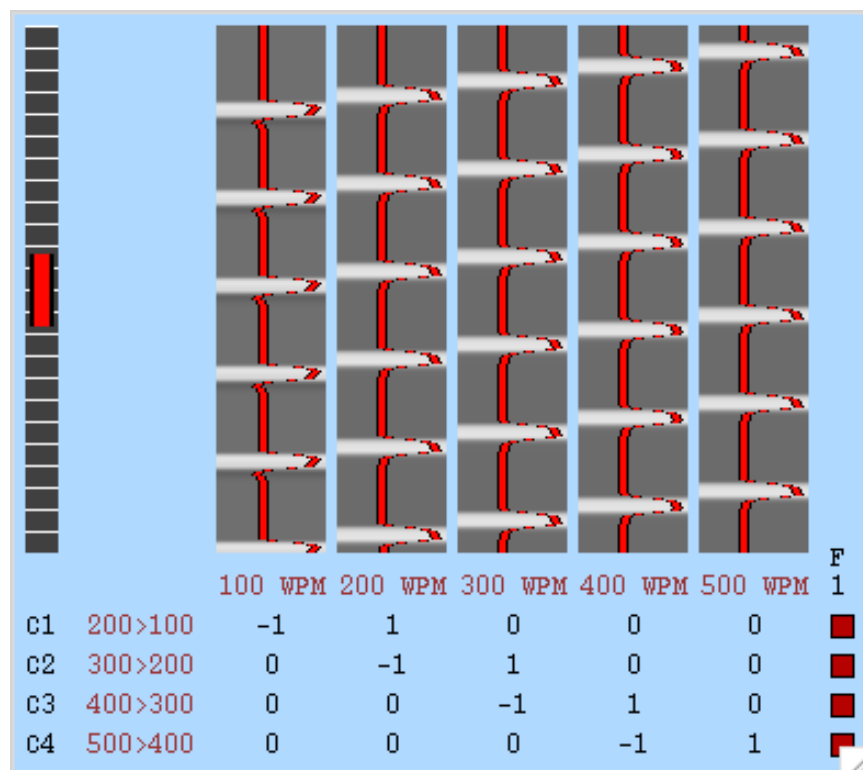
But ... that doesn't span all possible response, what about for example 300>100?

F-contrasts to the rescue

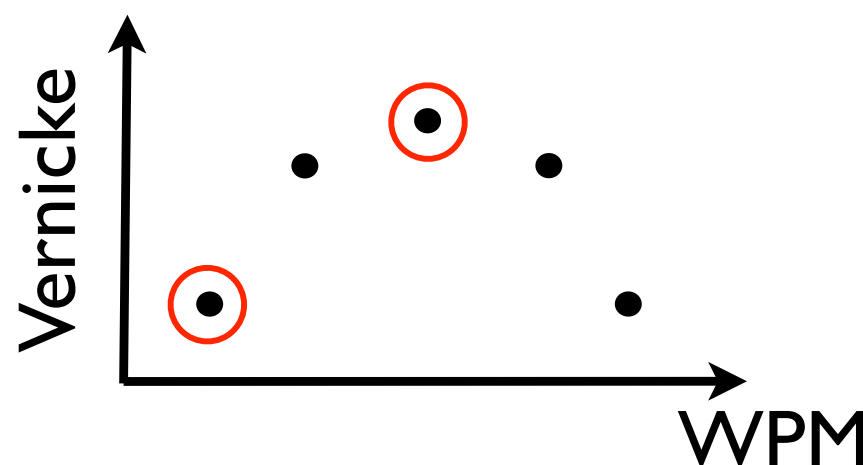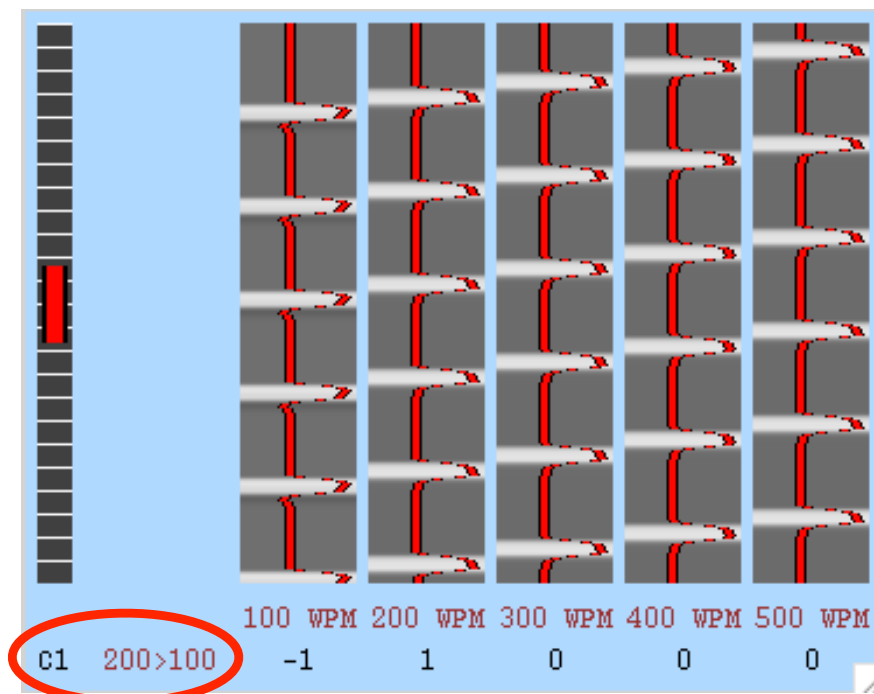|		100 WPM	200 WPM	300 WPM	400 WPM	500 WPM	F 1
c1	200>100	-1	1	0	0	0	■
c2	300>200	0	-1	1	0	0	■
c3	400>300	0	0	-1	1	0	■
c4	500>400	0	0	0	-1	1	■
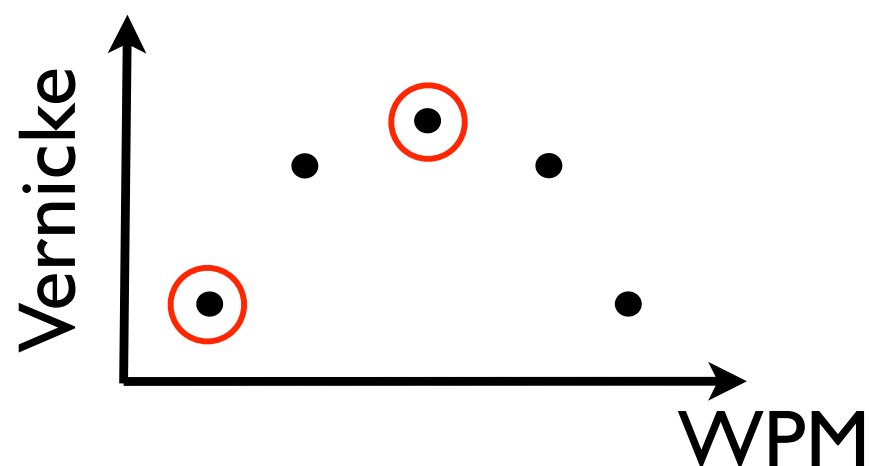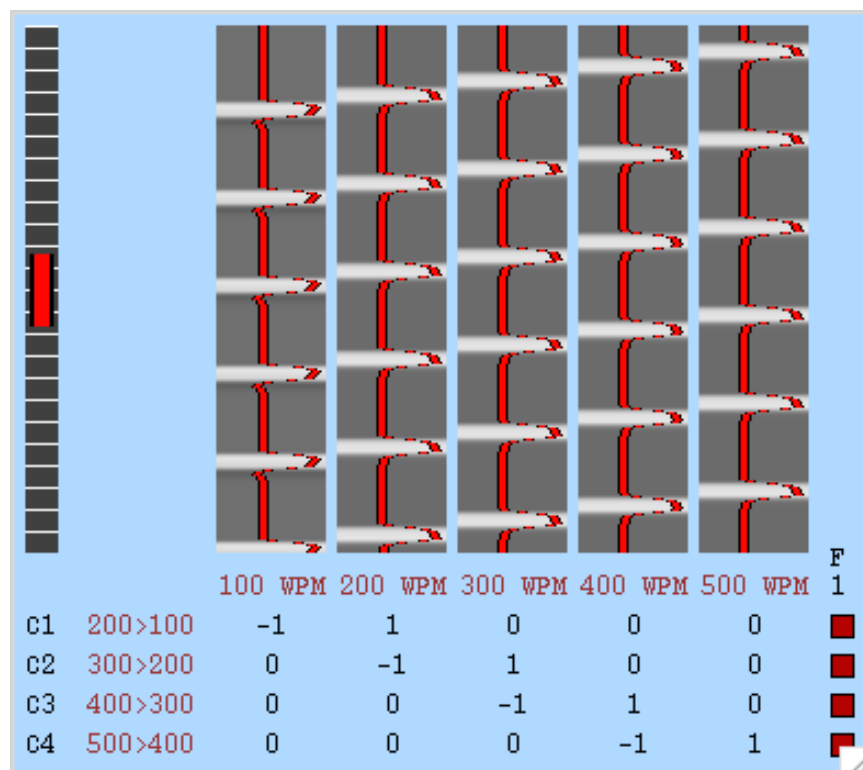
300>100 implies
200>100 AND/OR 300>200
which we have covered

But ... that doesn't span all possible response, what about for example 300>100?
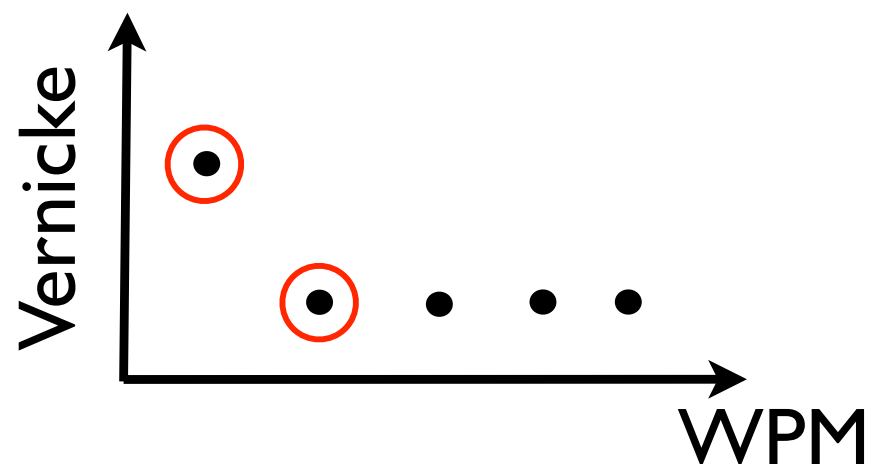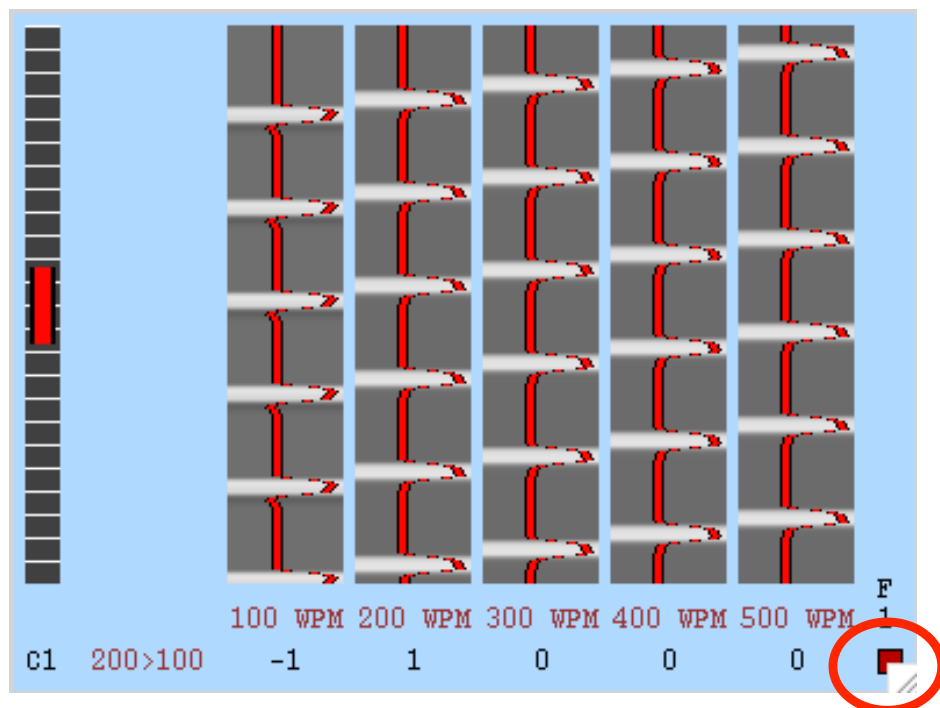

WPM

Vernicke

F-contrasts to the rescue

This *t*-contrast asks "where is 200>100?"

F-contrasts are bi-directional

But ... what about for example 100>200, you haven't covered that?

True story

F-contrasts to the rescue

100 WPM 200 WPM 300 WPM 400 WPM 500 WPM

C1 200>100 -1 1 0 0 0

But this F-contrast asks "where is 200 ≠ 100?"

F-contrasts are bi-directional

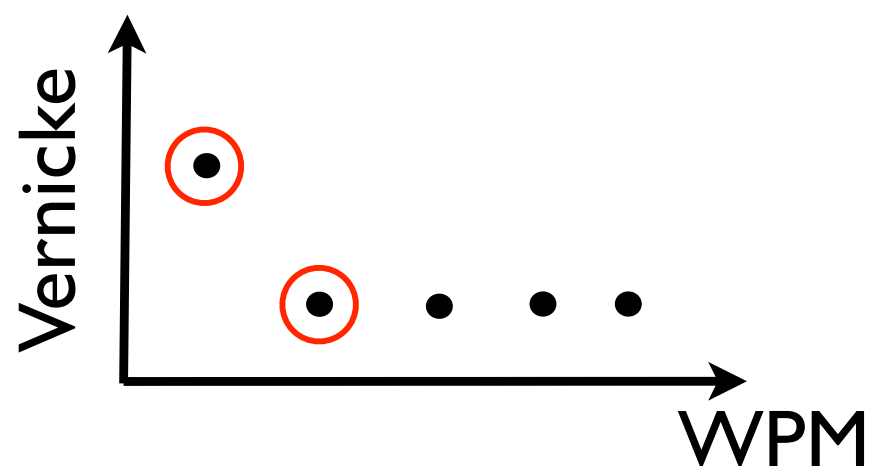But ... what about for example 100>200, you haven't covered that?

Vernicke

WPM

True story

Advanced Analysis: Parametric Designs

Summary:

- Important to have separate EVs (and parameters) per level of stimulus, otherwise assuming an exact linear response

- Linear trends require contrasts that are centred about zero and with even intervals

- Going beyond linear trends can be done with F-tests to look for arbitrary response shapes