Cognitive Modeling: Processing 2

Process Modeling & Neuroscience
Discovering processing stages

Chris Janssen

c.p.janssen@uu.nl
www.cpjanssen.nl

Questions last week?

Enrollment

- In groups of 3 for posters
- Personally for 3 papers as discussant?
- In groups of 2 for labs

Cognitive Modeling: Processing 2

Process Modeling & Neuroscience
Discovering processing stages

Chris Janssen

c.p.janssen@uu.nl
www.cpjanssen.nl

Intelligent tutor systems

- $2X + 7 = 27$

  $X = ?$
- Answer student: $x = 17$

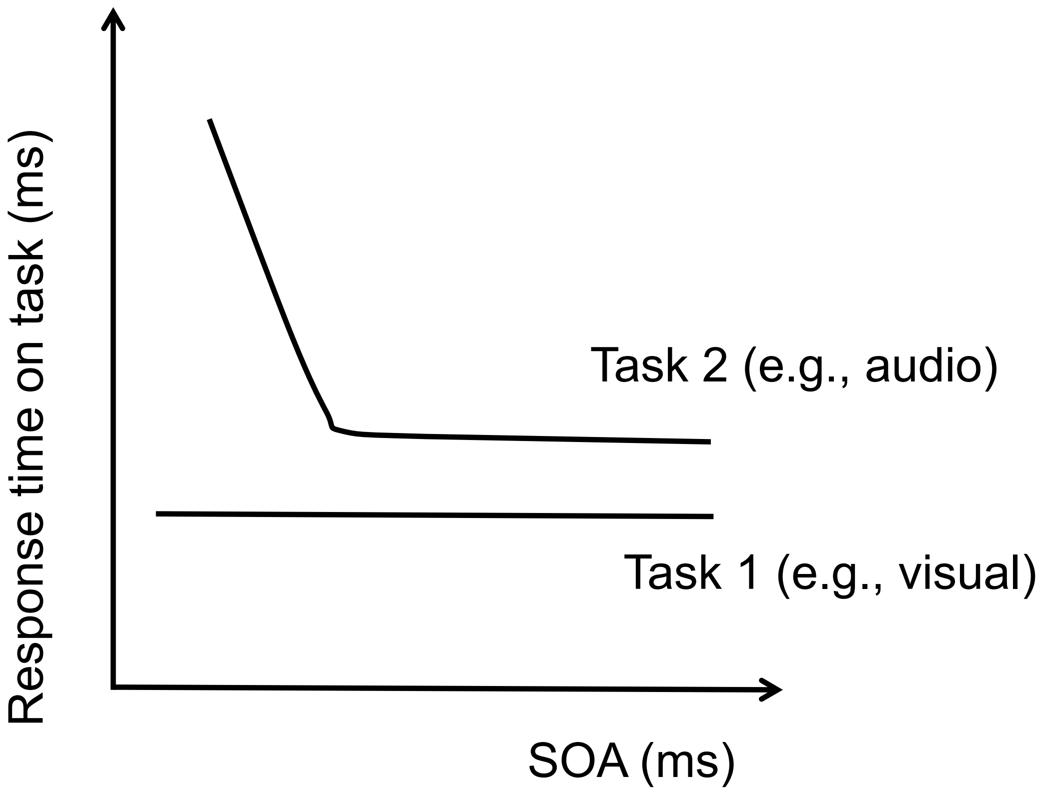
- Questions a tutor system addresses:
  - What went wrong?
  - What to practice next?
  - What instructions should be given?

Quality of (processing) models

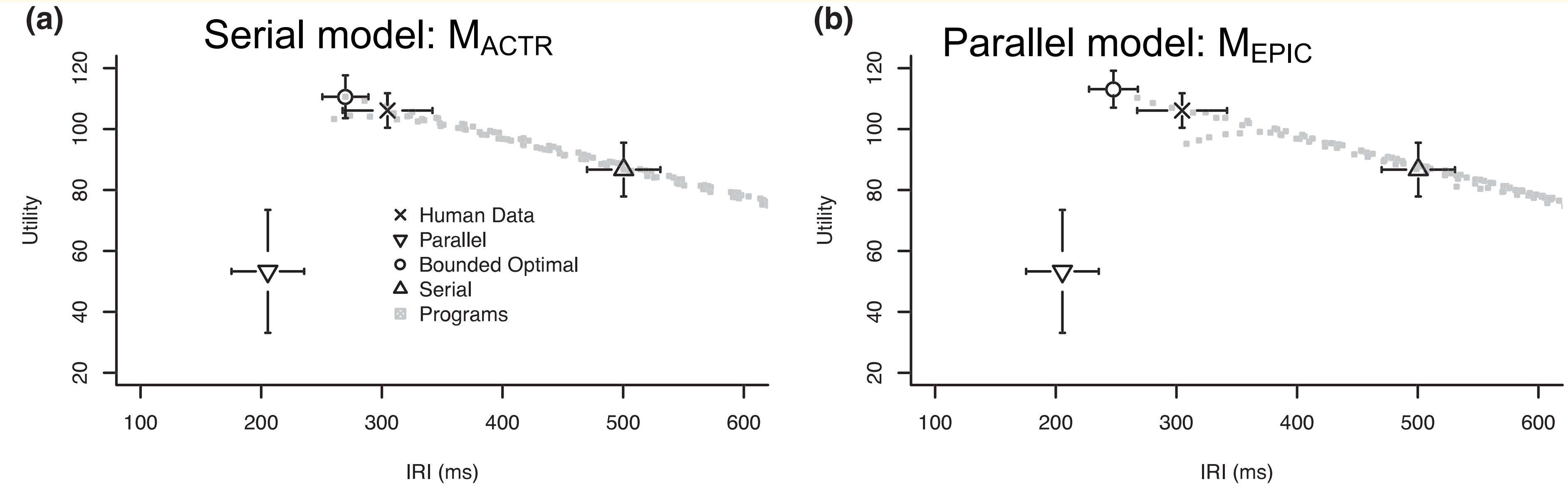
- How well are processes captured over time?

- Confidence in ***theory*** is needed to have confidence in ***application*** of theory
  - Tutor systems
  - Game opponents
  - User interface tests

Last week: PRP task



Last week: PRP task

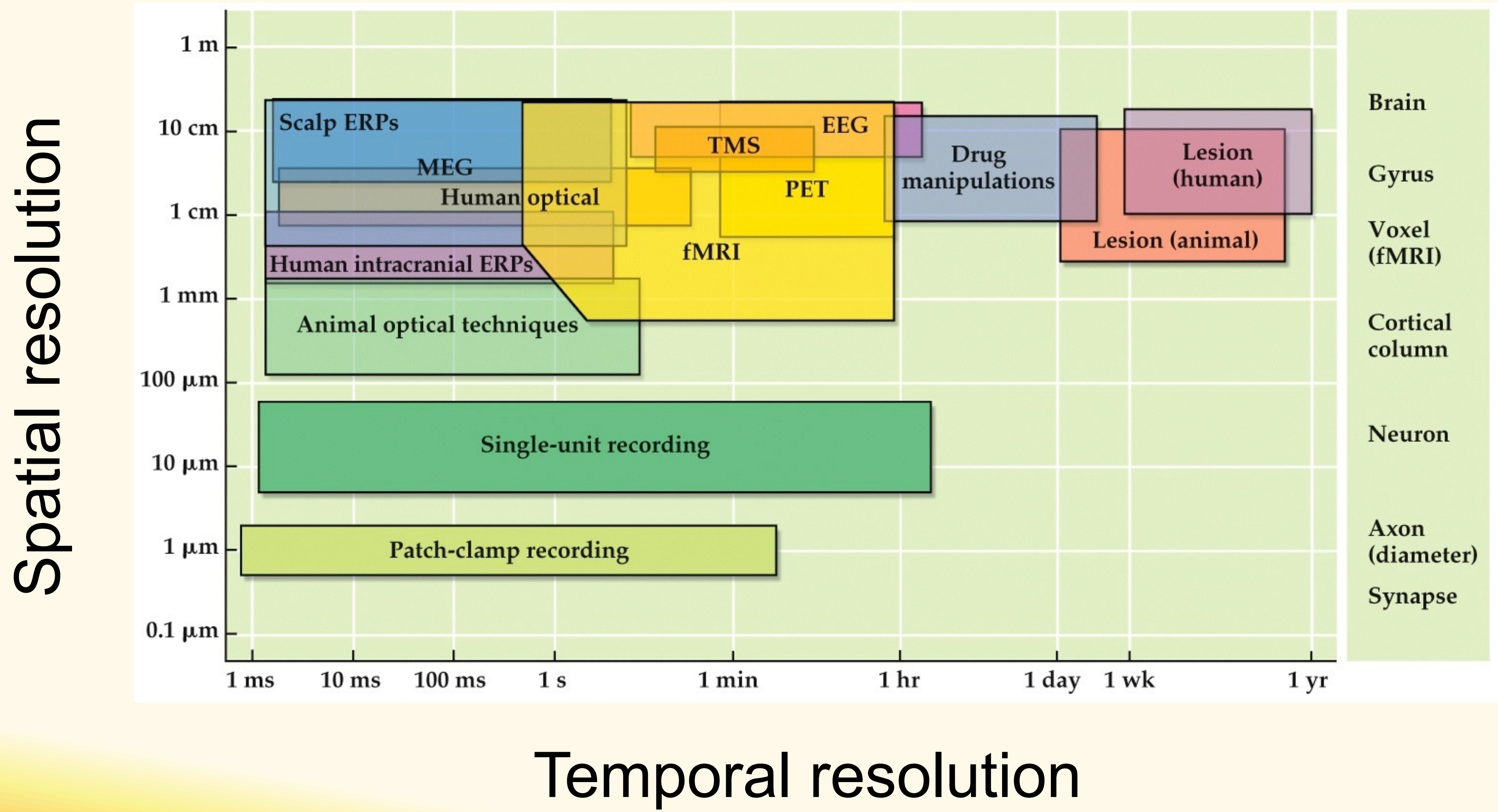


- Models fitted human data
- Did not give concluding evidence for ”central bottleneck”

Common (classic) (model-free) brain analyses

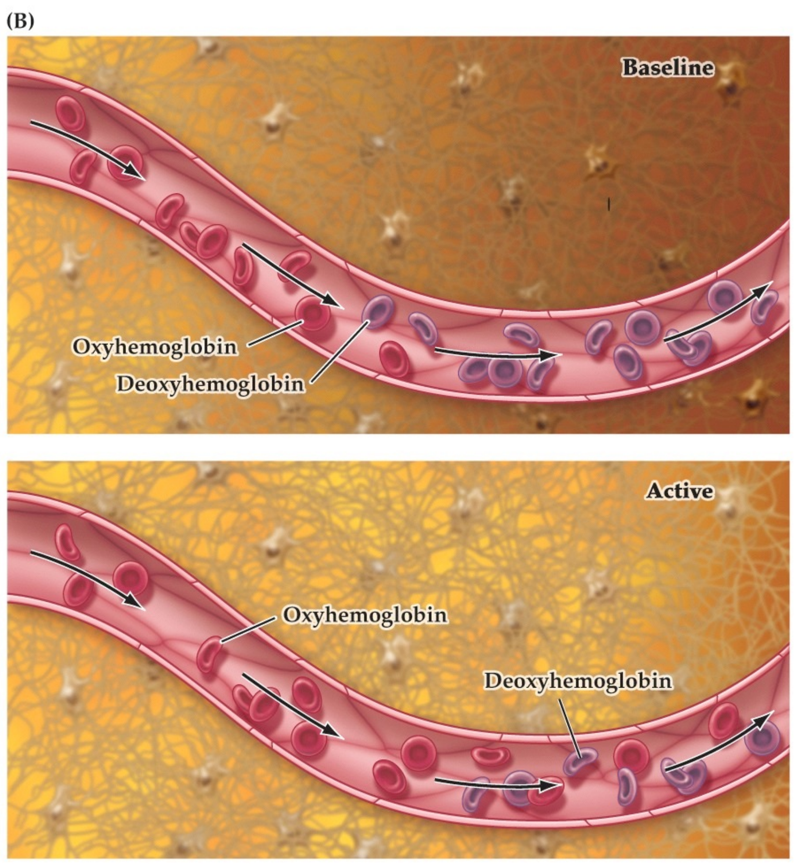
- **fMRI: functional Magnetic Resonance Imaging (Ben)**
- EEG – ElectroEncephaloGram
- ERP – Event Related Potential

Methods have trade-offs

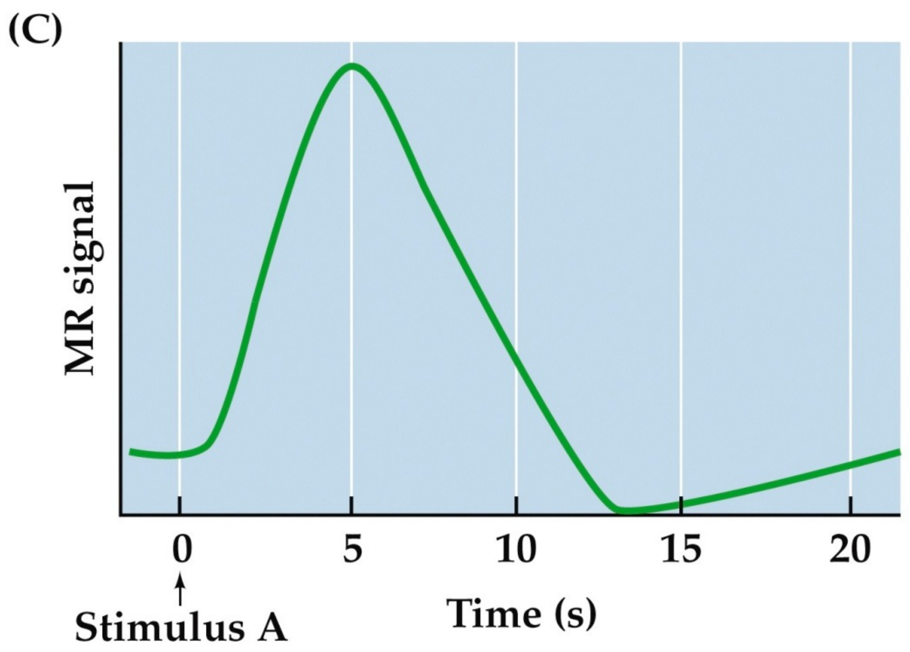


Purves et al. Fig 1.6

fMRI



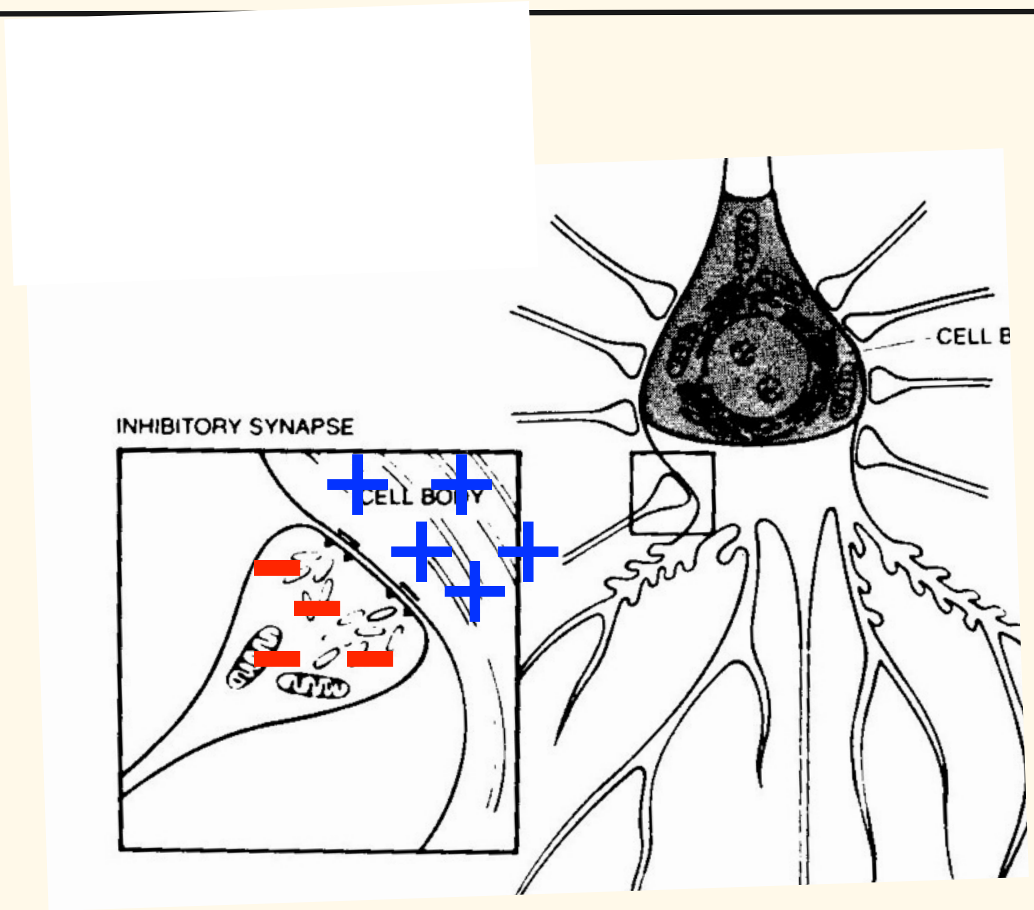
PRINCIPLES OF COGNITIVE NEUROSCIENCE 2e, Figure 2.12 (Part 2)



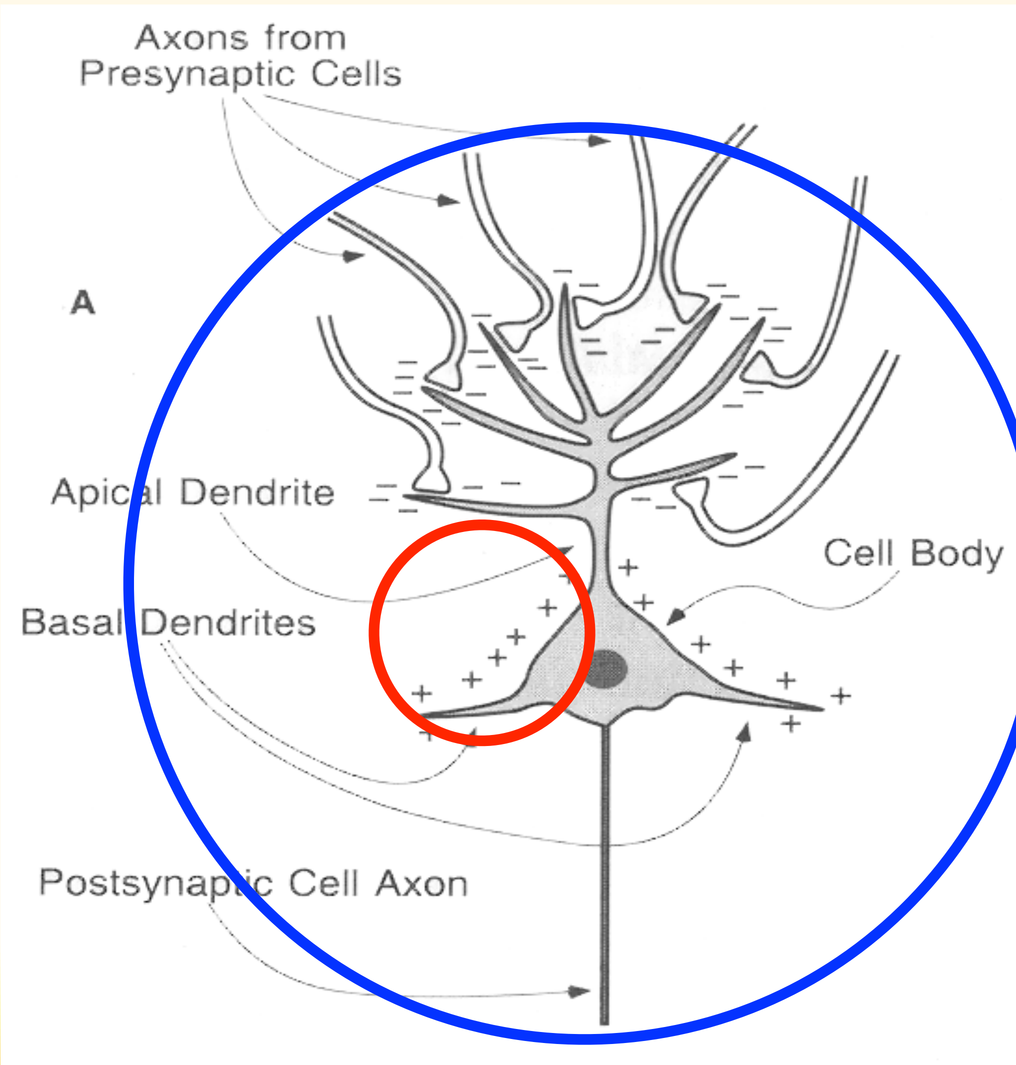
PRINCIPLES OF COGNITIVE NEUROSCIENCE 2e, Figure 2.13 (Part 3)

- **BOLD signal**
- **Lacks temporal precision (without a model)**

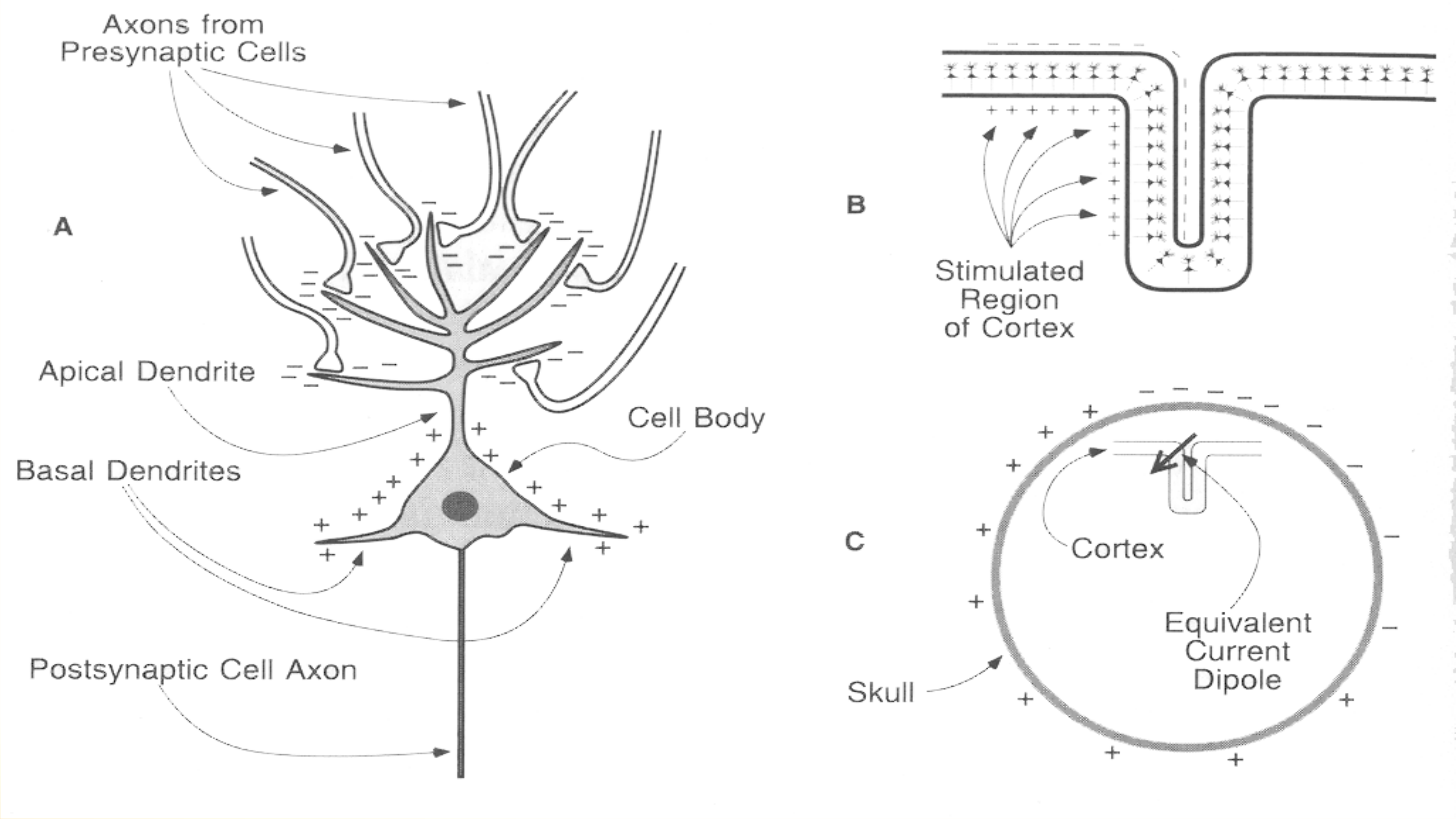
EEG



EEG

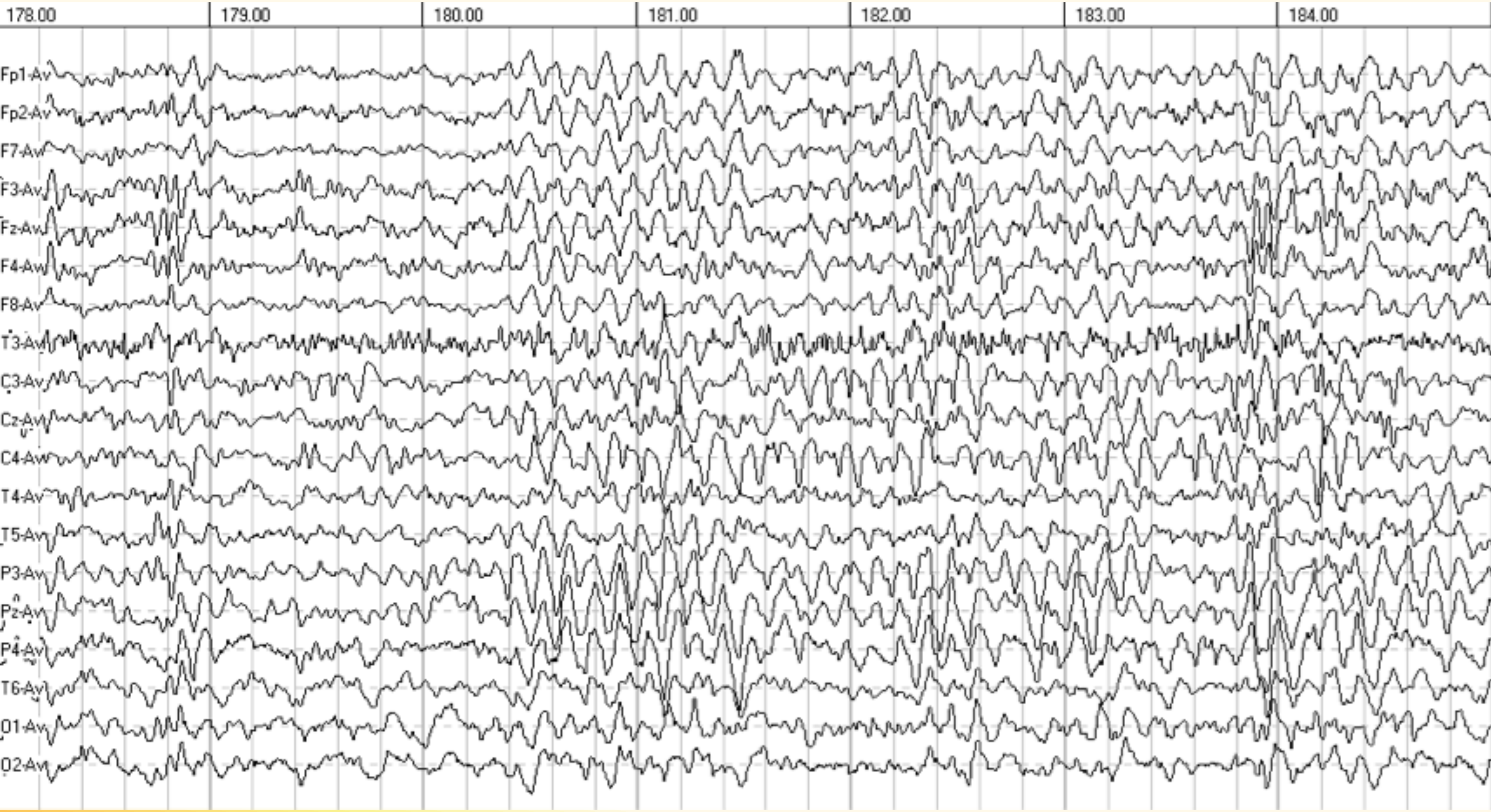

Axons from
Presynaptic Cells
A
Apical Dendrite
Cell Body
Basal Dendrites
Postsynaptic Cell Axon

EEG

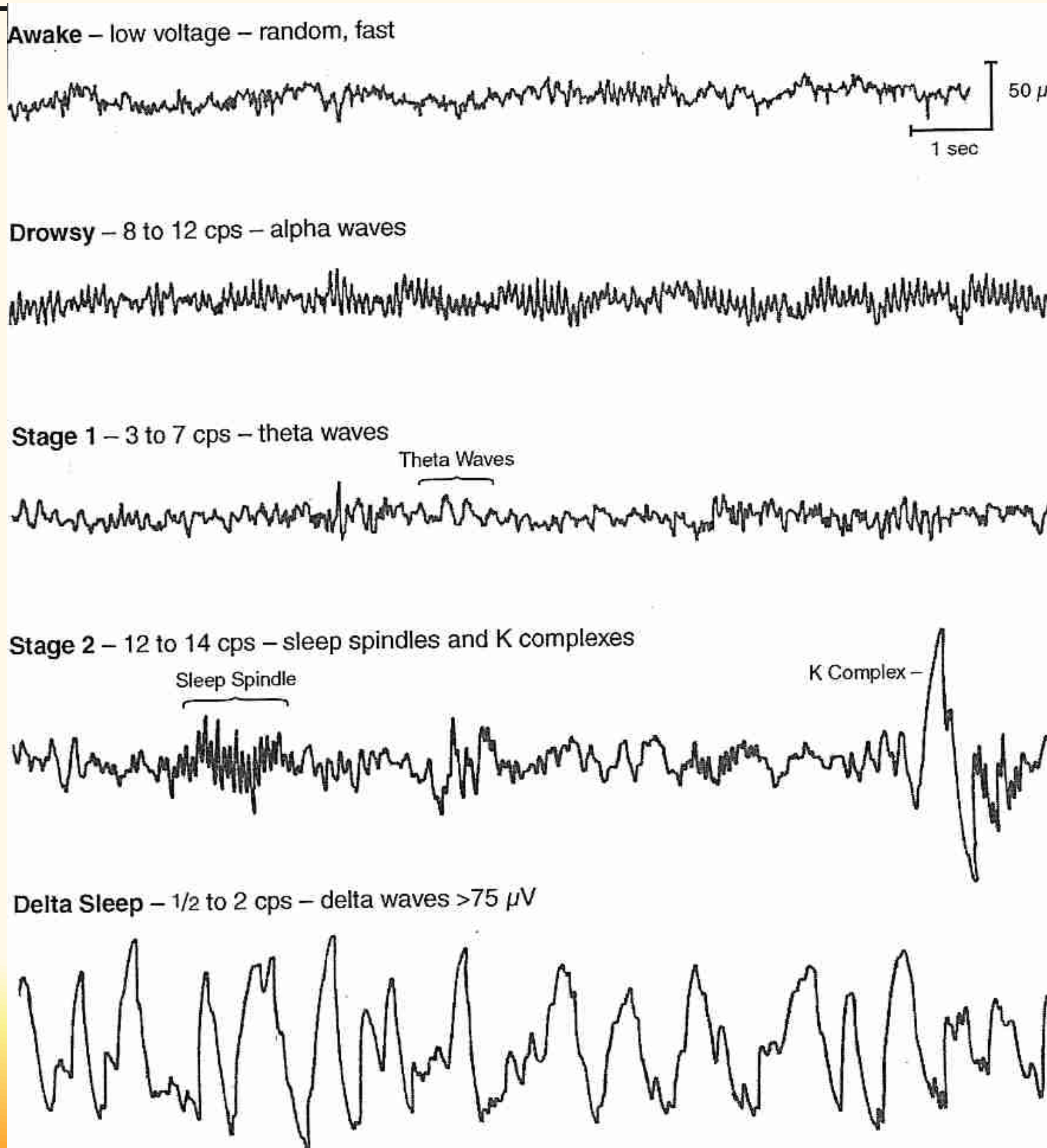


Axons from Presynaptic Cells
A
Apical Dendrite
Basal Dendrites
Cell Body
Postsynaptic Cell Axon
B
Stimulated Region of Cortex
C
Cortex
Equivalent Current Dipole
Skull

EEG output


178.00
179.00
180.00
181.00
182.00
183.00
184.00
Fp1-Av
Fp2-Av
F7-Av
F3-Av
Fz-Av
F4-Av
F8-Av
T3-Av
C3-Av
Cz-Av
C4-Av
T4-Av
T5-Av
P3-Av
Pz-Av
P4-Av
T6-Av
01-Av
02-Av

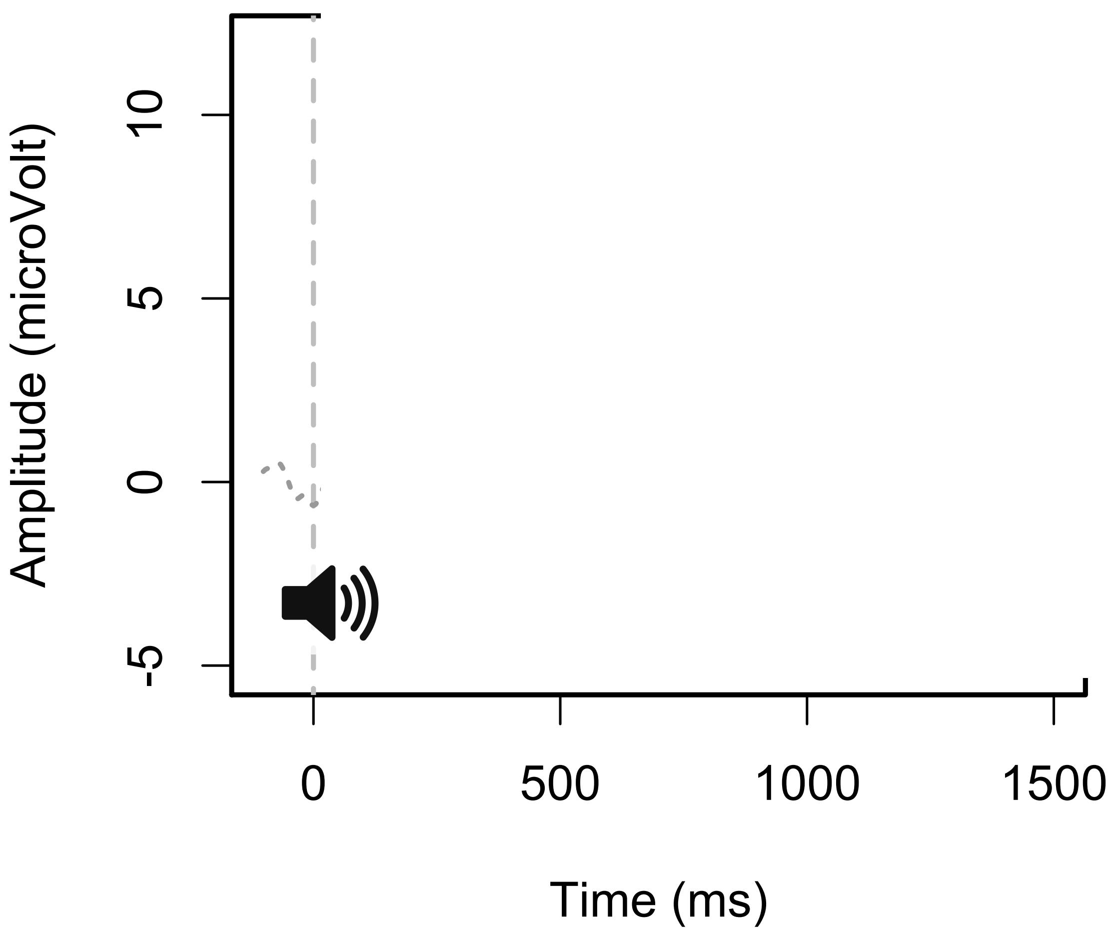
EEG output – rough phases/stage detection



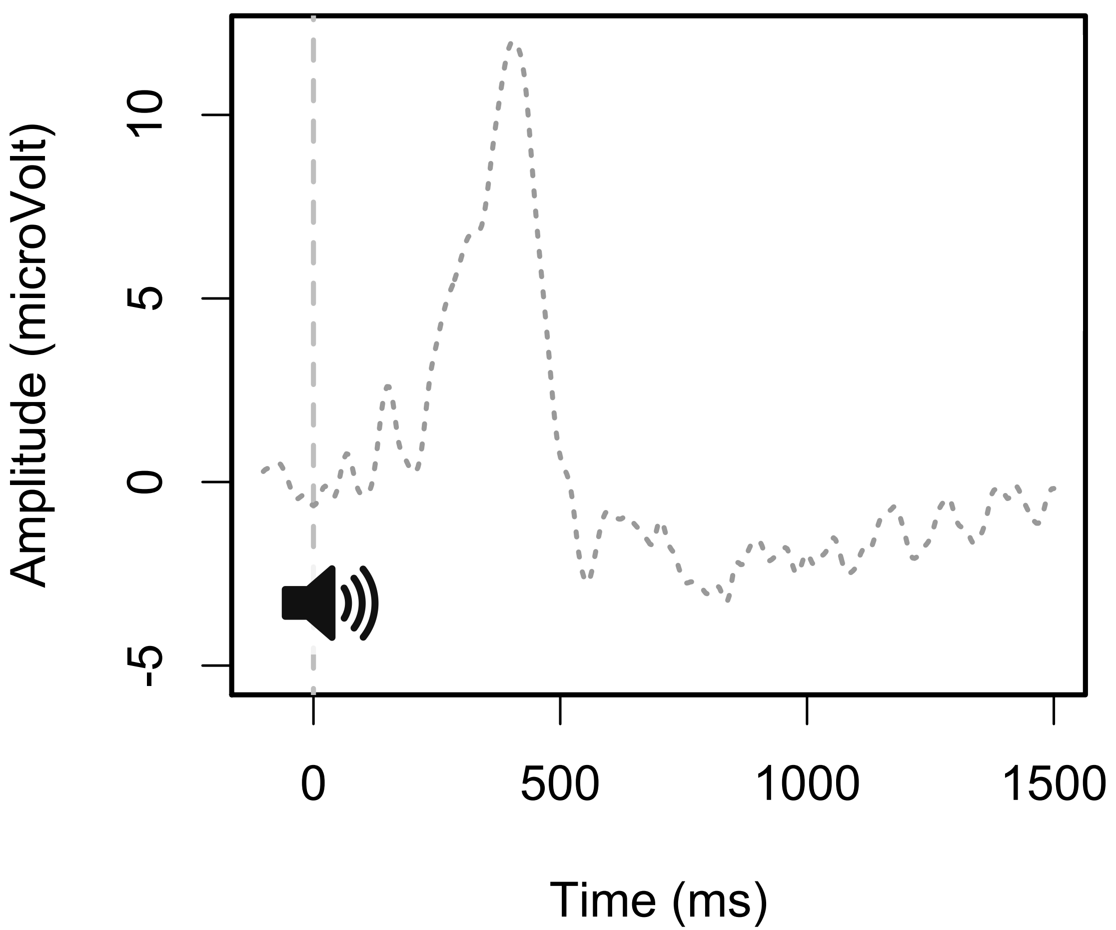
Limitation of raw EEG

- *Where* does activity come from?
  - Requires accumulation of theory (& associated models)

ERP



ERP



ERP

- **Response might reflect a process**
- **However….**
  - **Requires many trials; at group level**
  - **Only works good for processes close to stimulus onset / offset**
  - **Mostly *external* driven processes**
- **(some) modelers want to focus on:**
  - **(aggregate of) Individual trials**
  - **Actions triggered by external *& internal* processes**

Goal

- Can neuroscience inform process models?
- Can process models inform neuroscience?
  - Internal and externally triggered processes
  - Giving ***predictions*** for future studies and scenarios

- NB:
  - Interested in fMRI? Ask Martijn or Ben
  - Data collection will come back in Experimentation (block 3)

Psychological Review

0033-295X/16/$12.00 http://dx.doi.org/10.1037/rev0000030

The Discovery of Processing Stages: Extension of Sternberg's Method

John R. Anderson and Qiong Zhang
Carnegie Mellon University

Jelmer P. Borst
University of Groningen

Matthew M. Walsh
Carnegie Mellon University

We introduce a method for measuring the number and durations of processing stages from the electroencephalographic signal and apply it to the study of associative recognition. Using an extension of past research that combines multivariate pattern analysis with hidden semi-Markov models, the approach identifies on a trial-by-trial basis where brief sinusoidal peaks (called *bumps*) are added to the ongoing electroencephalographic signal. We propose that these bumps mark the onset of critical cognitive stages in processing. The results of the analysis can be used to guide the development of detailed process models. Applied to the associative recognition task, the hidden semi-Markov models multivariate pattern analysis method indicates that the effects of associative strength and probe type are localized to a memory retrieval stage and a decision stage. This is in line with a previously developed the adaptive control of thought–rational process model, called ACT-R, of the task. As a test of the generalization of our method we also apply it to a data set on the Sternberg working memory task collected by Jacobs, Hwang, Curran, and Kahana (2006). The analysis generalizes robustly, and localizes the typical set size effect in a late comparison/decision stage. In addition to providing information about the number and durations of stages in associative recognition, our analysis sheds light on the event-related potential components implicated in the study of recognition memory.

Keywords: associative recognition, computational modeling, reaction time, hidden semi-Markov models, EEG

Even before the emergence of experimental psychology as a scientific field, it was apparent that a number of "stages" underlie

1979; Roberts & Sternberg, 1993; Schweickert, Fisher, & Goldstein, 2010). The typical approach to evaluating these accounts is

Today’s topics

Process modeling & neuroscience

1. Why do we want to know the details?
2. Why are models useful for neuroscience & why is neuroscience useful for models?
3. **What is the associative recognition task? What is the (ACT-R) process model of this task?**
4. **What can we learn using a “bottom-up” approach (machine learning without theory)?**
5. **What is the value of combining this with a process model?**
6. **What are the seven features of the approach and why are they needed? (page 2-4)**

- **Poster presentations**

Associative recognition task

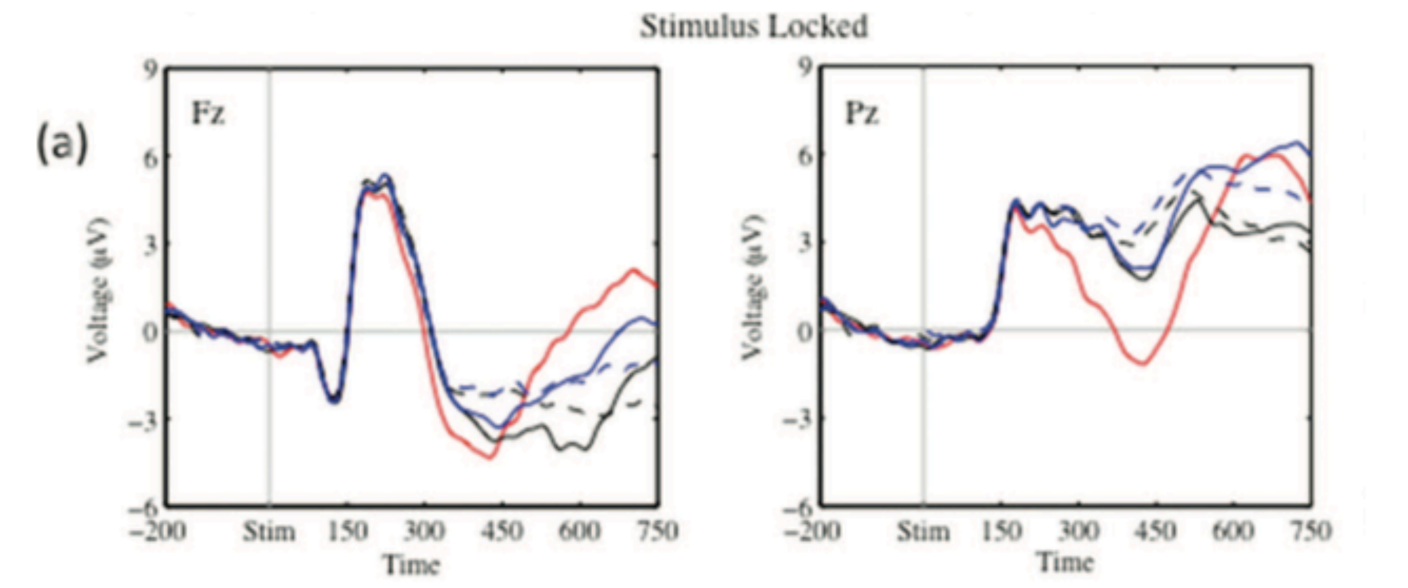
Study phase
Flame–cape
Metal–motor
Metal–spark
Jelly–motor
Book–deck
House–peach
Flag–peach
. . .

Associative recognition task

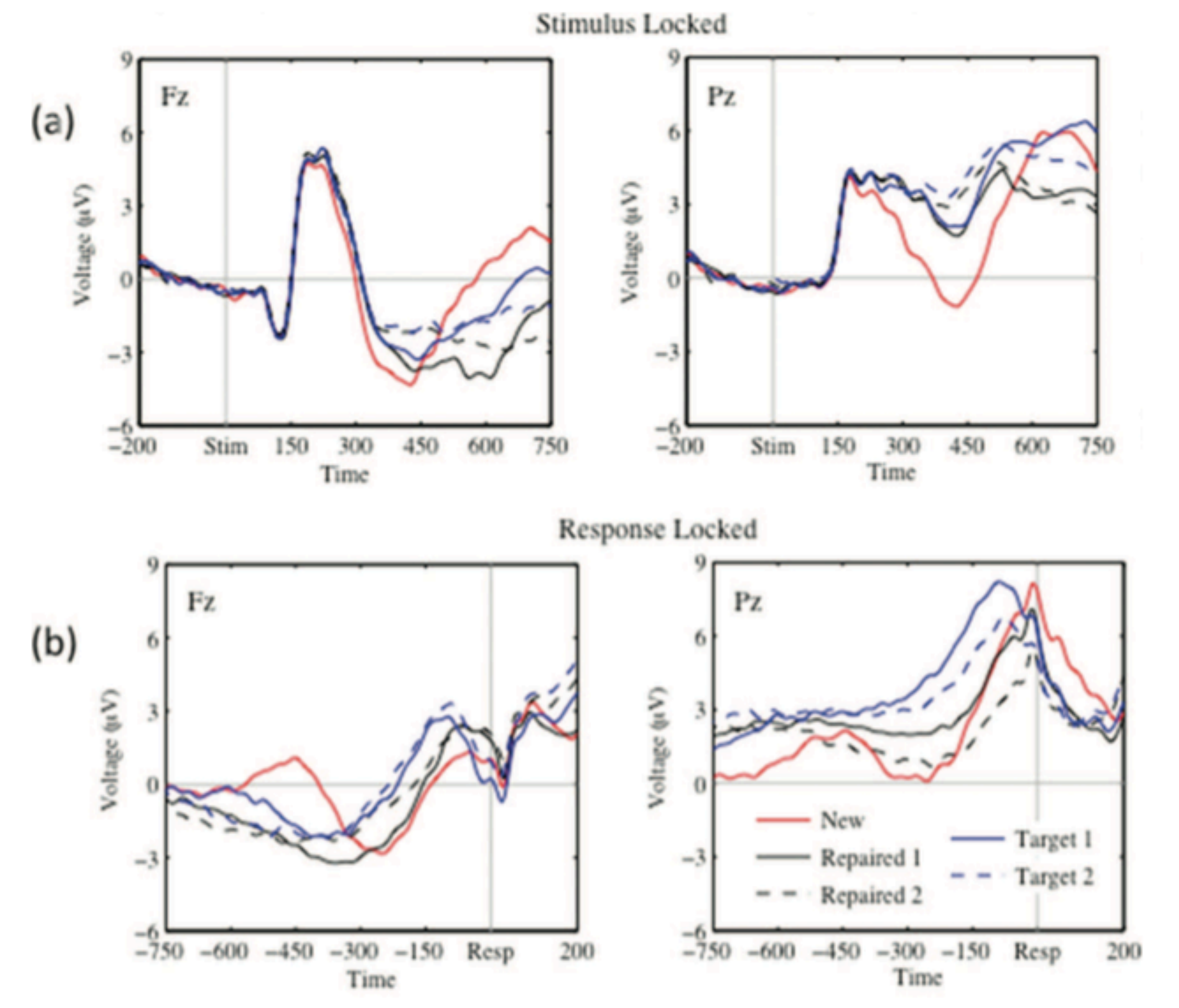
Study phase	Test phase	Condition	Error rate	Latency (ms)[a]	Useable trials
Flame–cape	Flame–cape	Fan 1 target	3.1%	994	3,767
Metal–motor	Metal–motor	Fan 2 target	6.7%	1,189	3,473
Metal–spark	Flame–deck	Fan 1 foil	3.1%	1,061	3,714
Jelly–motor	Metal–peach	Fan 2 foil	6.0%	1,342	3,444
Book–deck	Jail–giant	New foil	.1%	702	3,873
House–peach					
Flag–peach					
. . .					

[a] Mean latencies are from useable trials only.

‘classic’ ERP analysis: only part of process



‘classic’ ERP analysis: only part of process



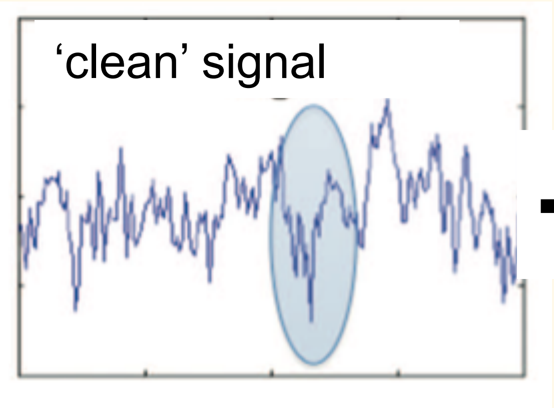
A bottom-up (machine learning) approach

- General theory:
  New process reveals a ‘bump’ in activity
  - 2 interpretations of what this means (see paper)

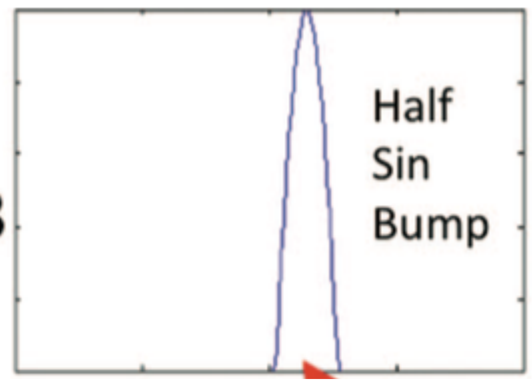
- Machine learning technique (HSMM):
  - How many bumps are there?
  - Where are they?

Bumps' effect on a signal

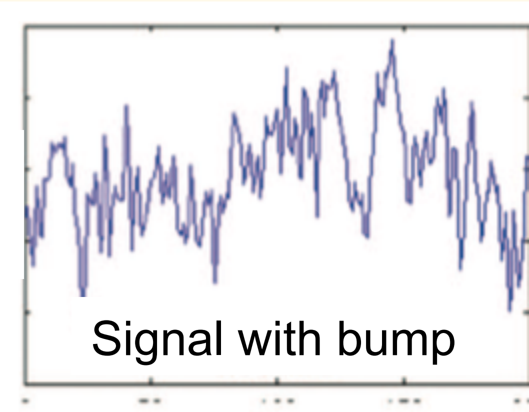
Generating a bump



+ 1/3

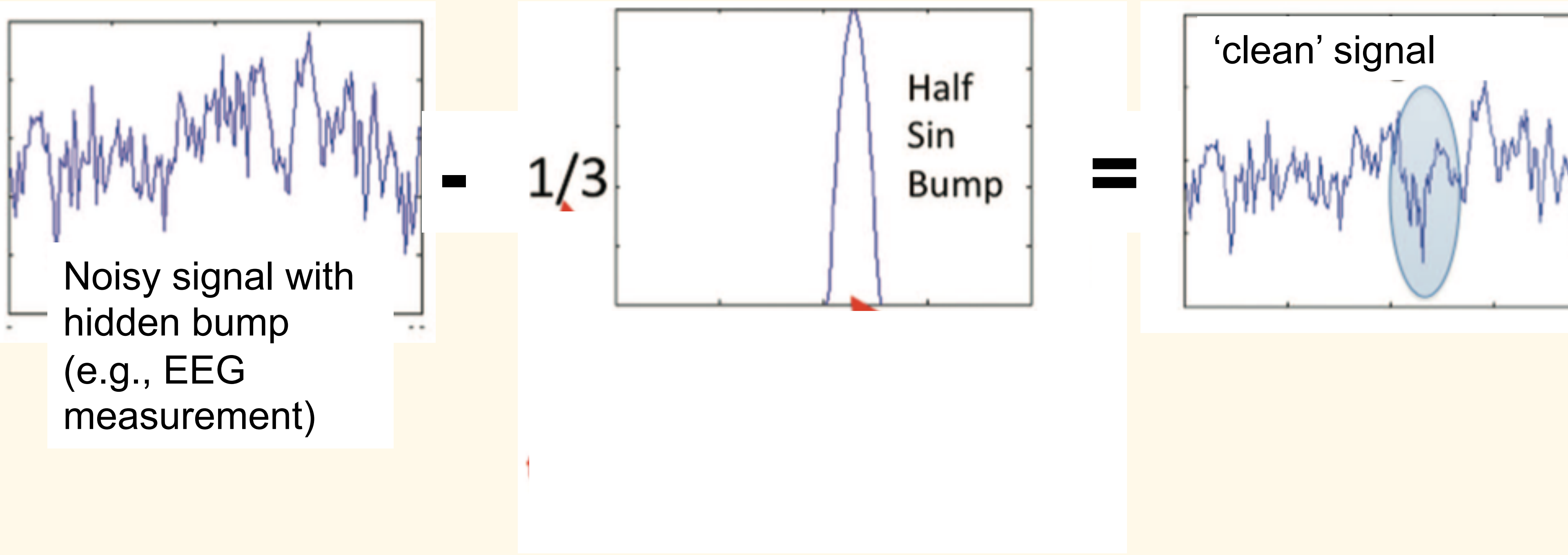


=



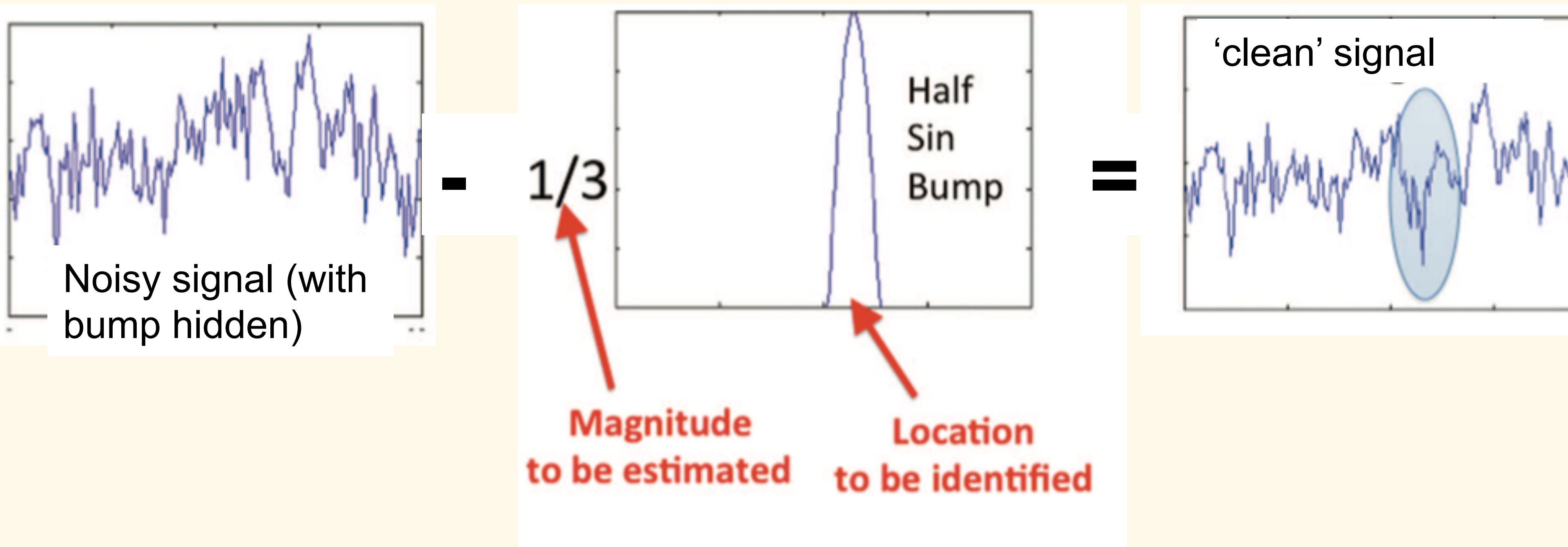
Bumps' effect on a signal

Reverse engineering where a bump is



Bumps' effect on a signal

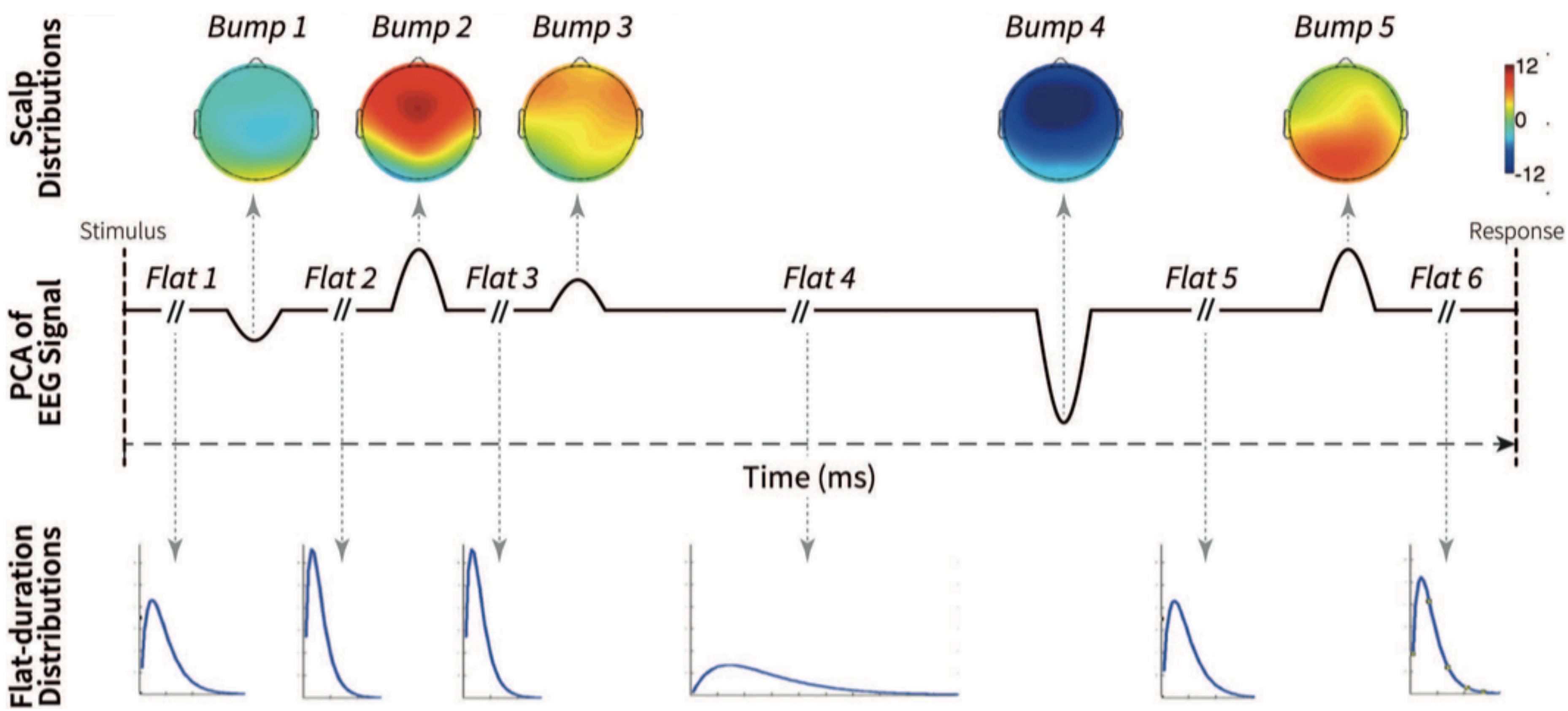
Reverse engineering where a bump is



A bottom-up (machine learning) approach

1. Measure EEG activity at high temporal & spatial resolution
2. Data reduction: 10 spatial PCAs & down sampling to 100 Hz
3. Model what 1 Bump (50ms) looks like (**variables**: magnitude & when/location)
4. Model what 1 flat looks like (Gamma-2 with **variable** shape)
5. Explore HSMM for N-bumps.
6. Optimize model fits of all **variables** with this model

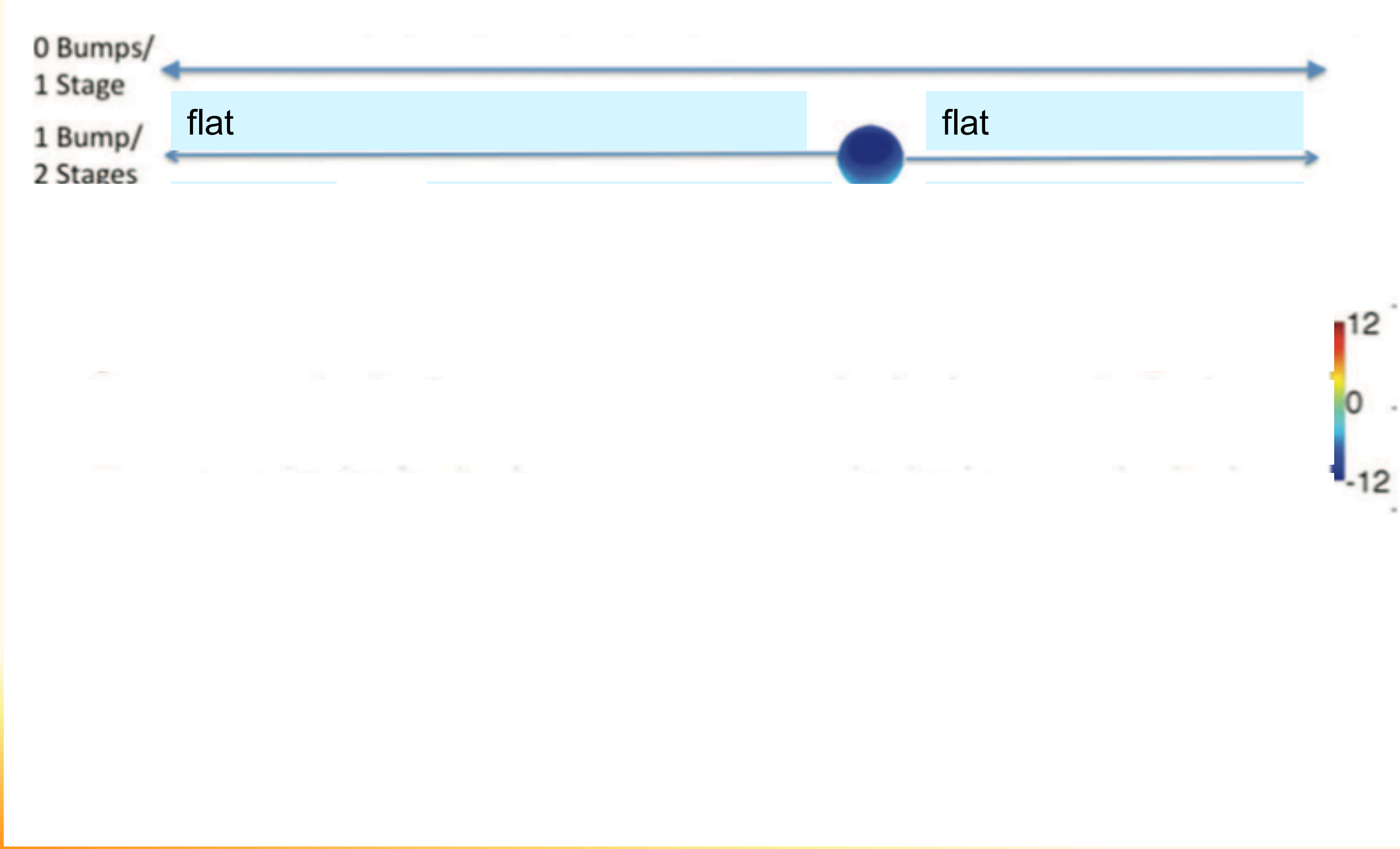
A bottom-up (machine learning) approach



1. Measure EEG activity at high temporal & spatial resolution
2. Data reduction: 10 spatial PCAs & down sampling to 100 Hz
3. Model what 1 Bump (50ms) looks like (**variables**: magnitude & when/location)
4. Model what 1 flat looks like (Gamma-2 with **variable** shape)
5. Explore HSMM for N-bumps.
6. Optimize model fits of all **variables** with this model

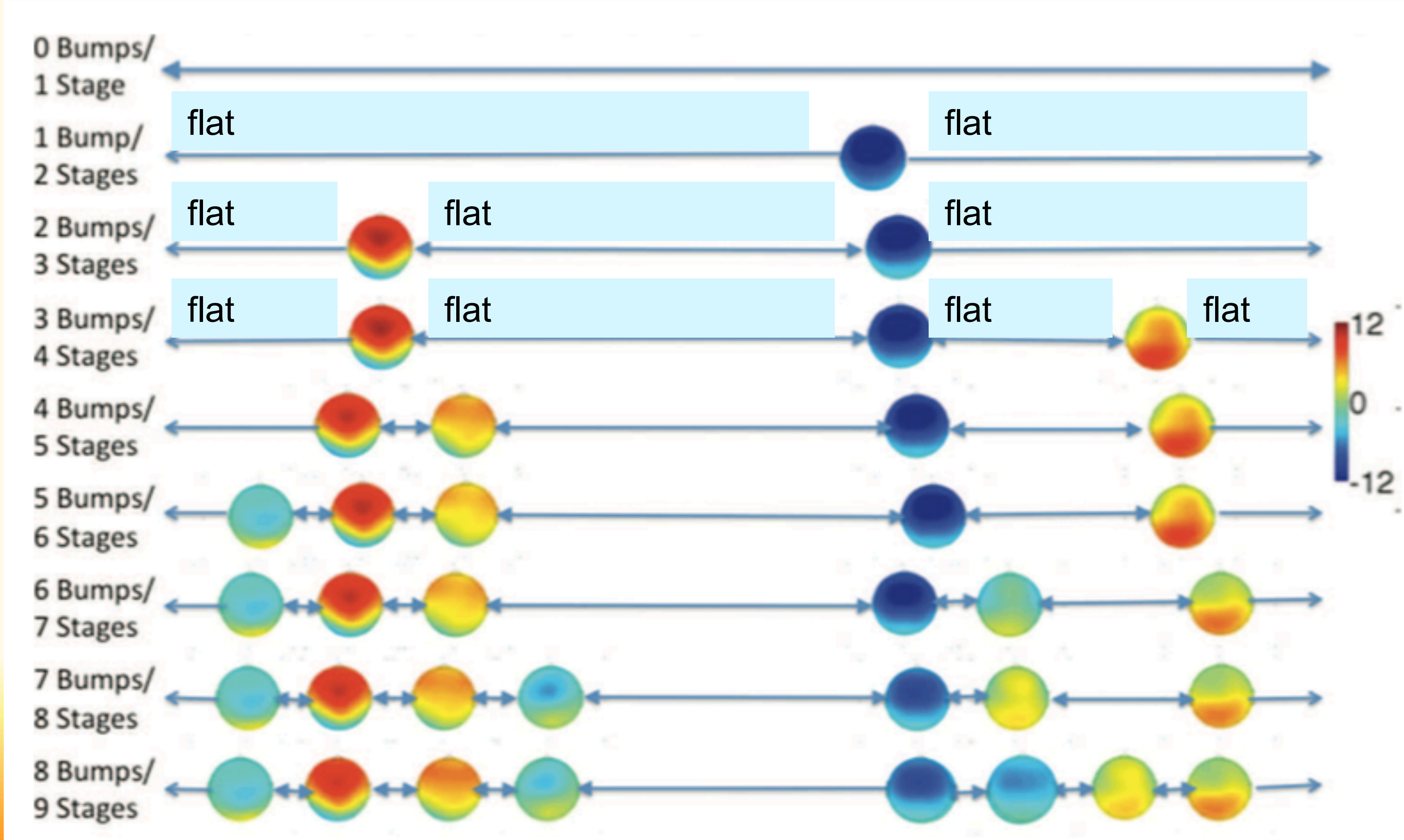
A bottom-up (machine learning) approach

- **Naïve about exact nr bumps**



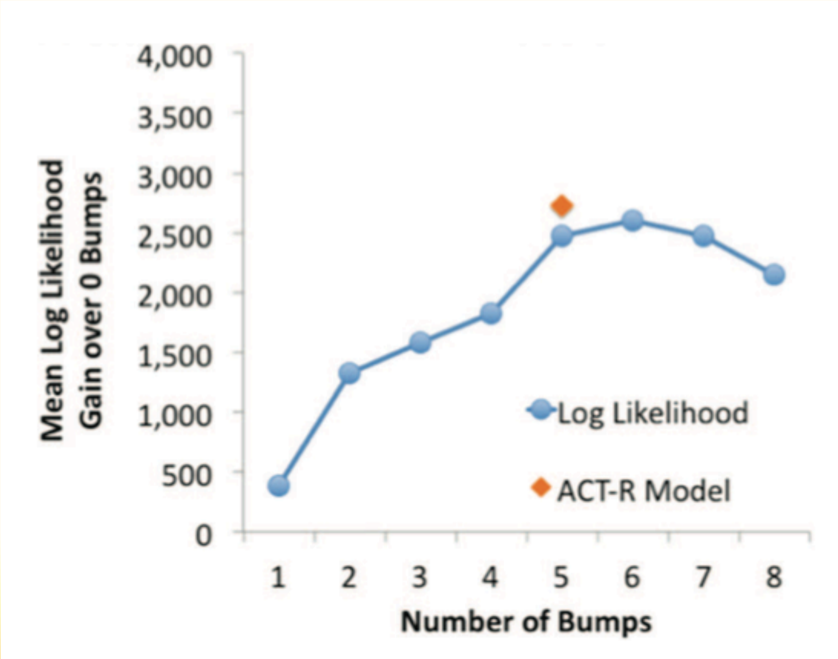
A bottom-up (machine learning) approach

- **Naïve about exact nr bumps**



A bottom-up (machine learning) approach

- **Naïve about exact nr bumps**
  - Explore all options
  - Check what nr bumps gives best improvement
    (here LOOCV with criterion "better for 12 / 20 subjects")



A bottom-up (machine learning) approach

- Reliable identifications of flats and bumps
- But…
  - No understanding WHY
  - What are stages? What are latencies?

- Requires a model

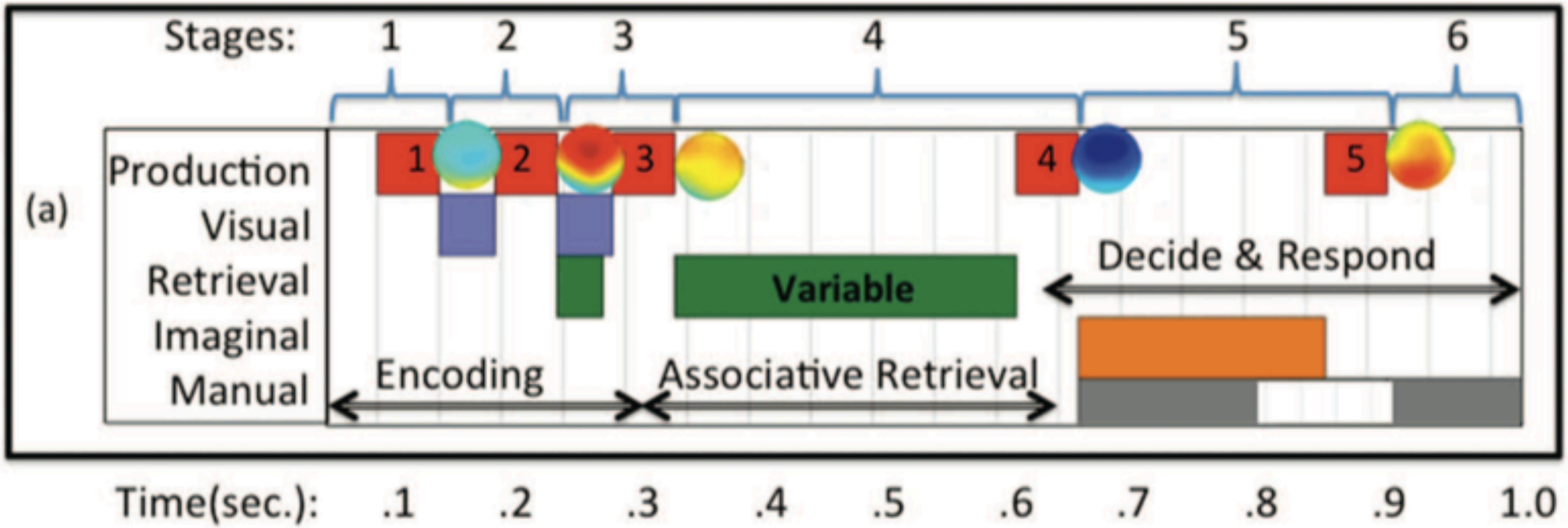
Today’s topics

Process modeling & neuroscience

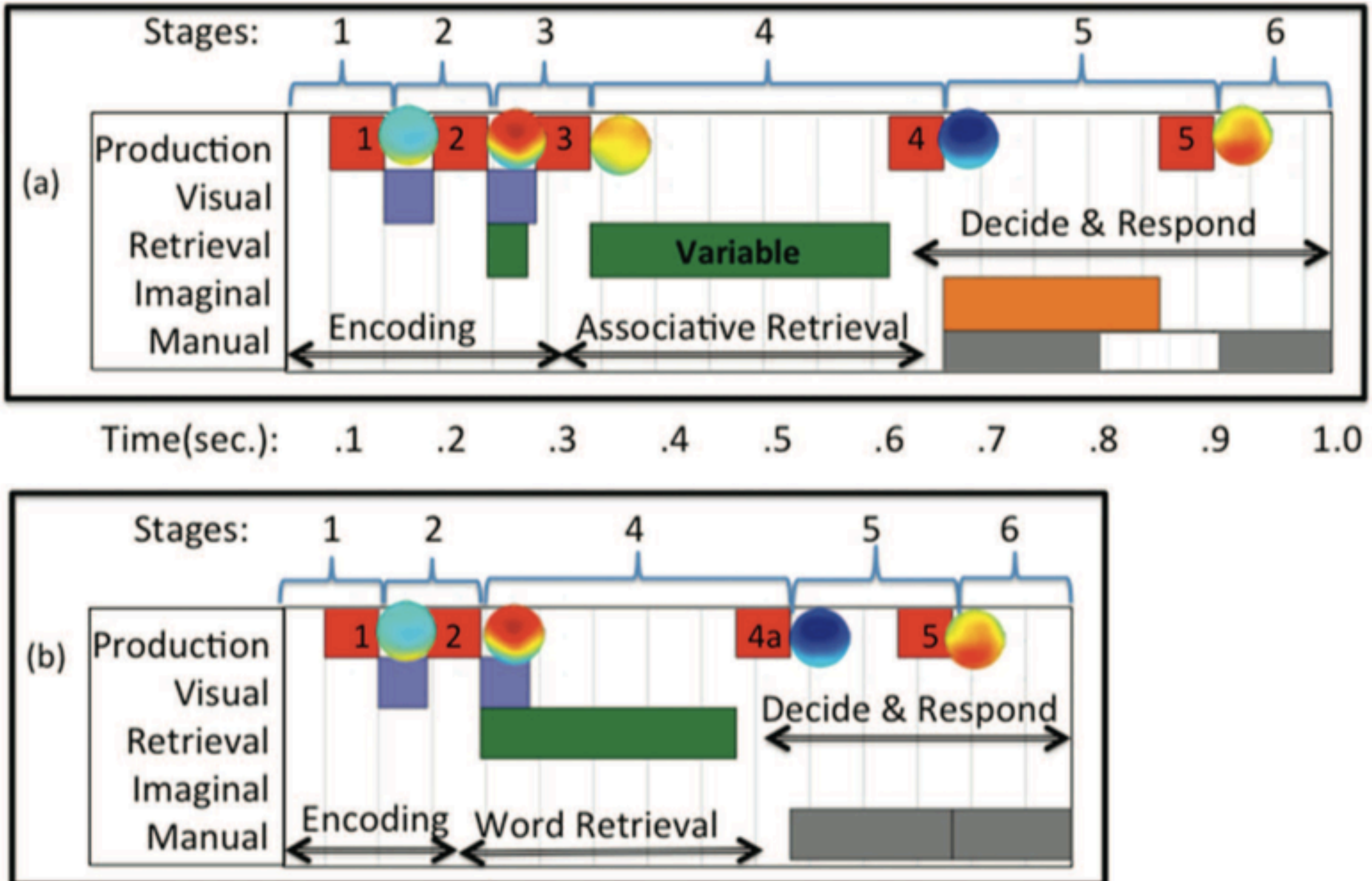
1. Why do we want to know the details?
2. Why are models useful for neuroscience & why is neuroscience useful for models?
3. What is the associative recognition task? **What is the (ACT-R) process model of this task?**
4. What can we learn using a “bottom-up” approach (machine learning without theory)?
5. **What is the value of combining this with a process model?**
6. **What are the seven features of the approach and why are they needed? (page 2-4)**

- **Poster presentations**

ACT-R Process model



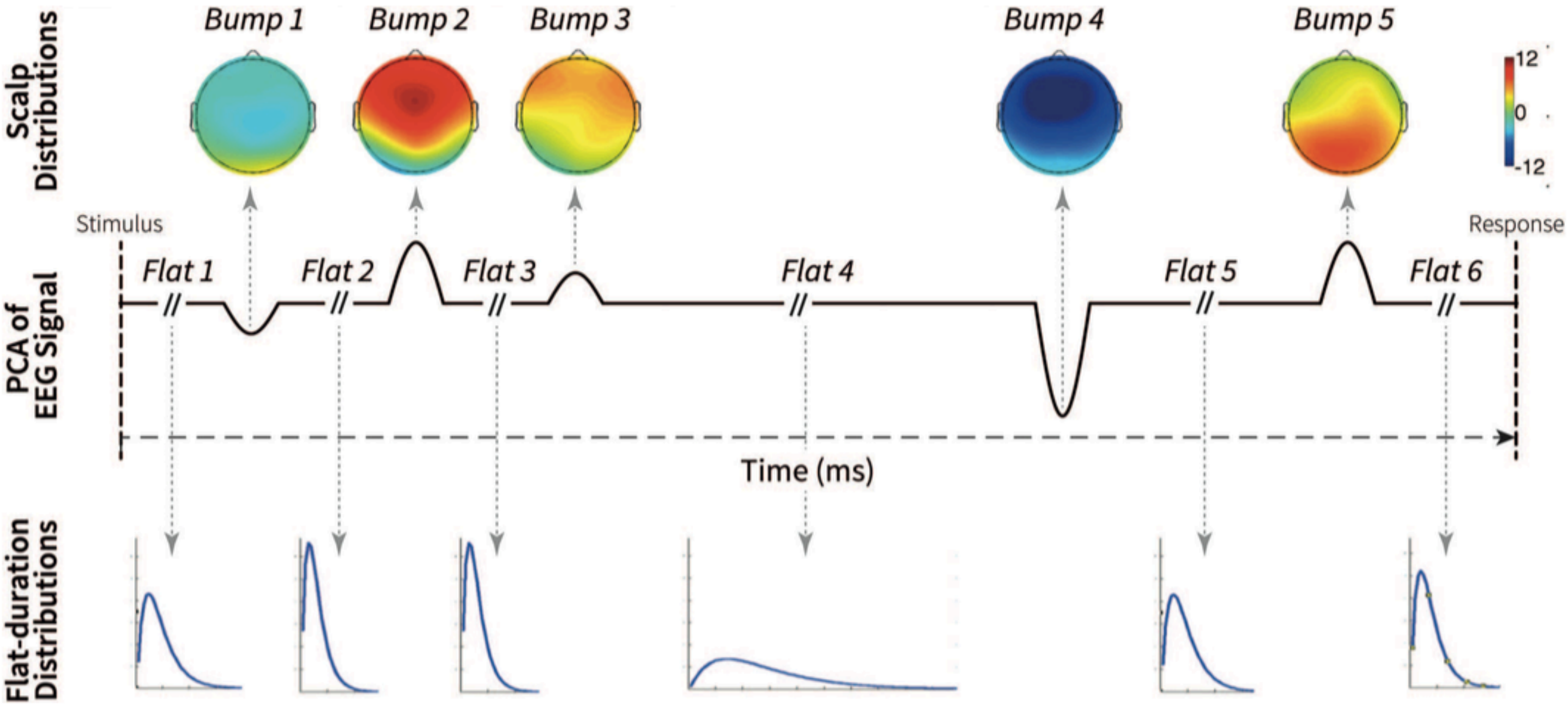
ACT-R Process model



Combining process model with EEG

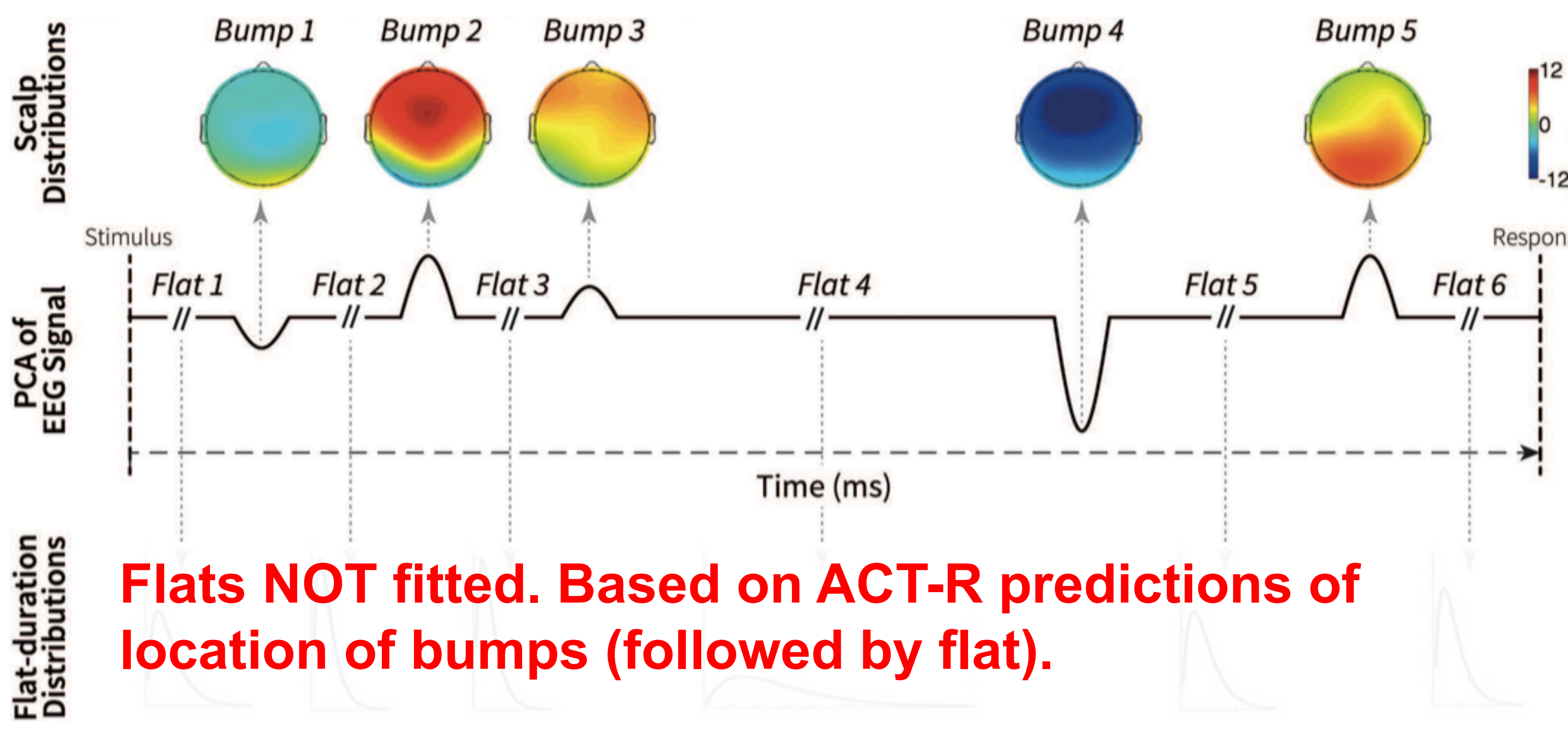
- **ACT-R model predicts:**
  - Number of bumps
  - Timing of bumps
- **Assumption of model:**
  - Bump is associated with moment a production rule fires

A bottom-up (machine learning) approach



1. Measure EEG activity at high temporal & spatial resolution
2. Data reduction: 10 spatial PCAs & down sampling to 100 Hz
3. Model what 1 Bump (50ms) looks like (**variables**: magnitude & when/location)
4. Model what 1 flat looks like (Gamma-2 with **variable** shape)
5. Explore HSMM for N-bumps.
6. Optimize model fits of all **variables** with this model

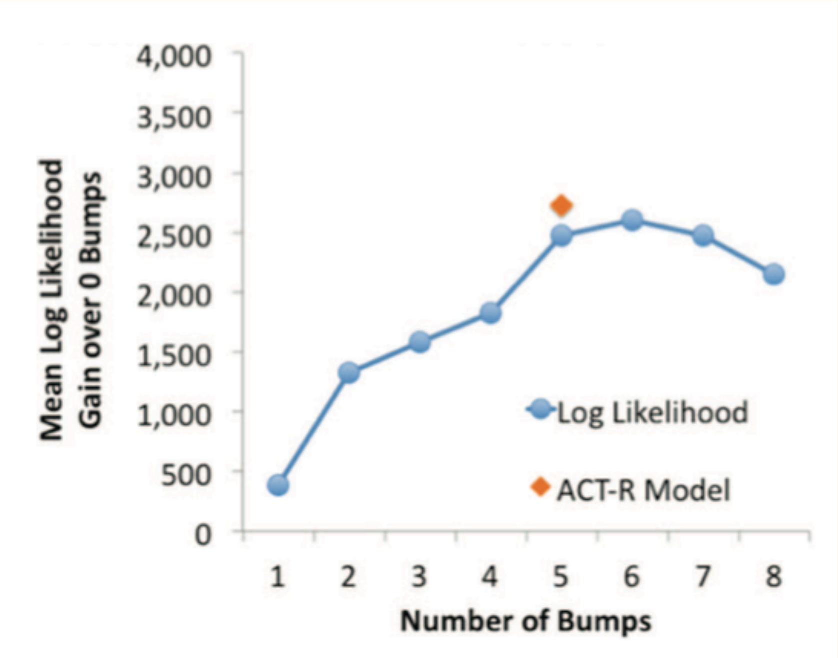
Combining process model with EEG



1. Measure EEG activity at high temporal & spatial resolution
2. Data reduction: 10 spatial PCAs & down sampling to 100 Hz
3. Model what 1 Bump (50ms) looks like (**variables**: magnitude ~~& when/location~~)
4. ~~Model what 1 flat looks like (Gamma-2 with **variable** shape)~~
5. Explore HSMM for ~~N-bumps~~ 5 bumps
6. Optimize model fits of ~~all **variables**~~ **variable magnitude** with this model

Compare bottom-up vs ACT-R HSMM

- ACT-R has better LOOCV scores
- Despite having fewer parameters to fit!!!
- Times of each stage similar between ACT-R and bottom-up model (Figure 11)



Today’s topics

Process modeling & neuroscience

1. Why do we want to know the details?
2. Why are models useful for neuroscience & why is neuroscience useful for models?
3. What is the associative recognition task? What is the (ACT-R) process model of this task?
4. What can we learn using a “bottom-up” approach (machine learning without theory)?
5. **What is the value of combining this with a process model?**
6. **What are the seven features of the approach and why are they needed? (page 2-4)**

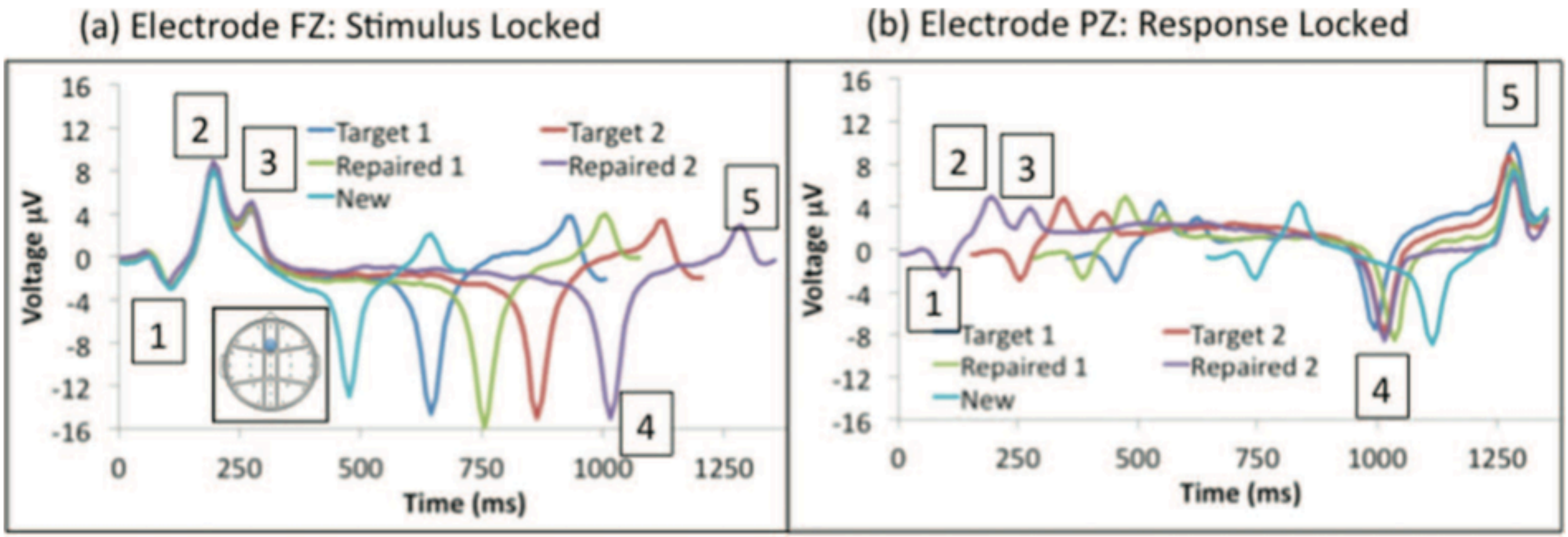
- **Poster presentations**

Value of approach

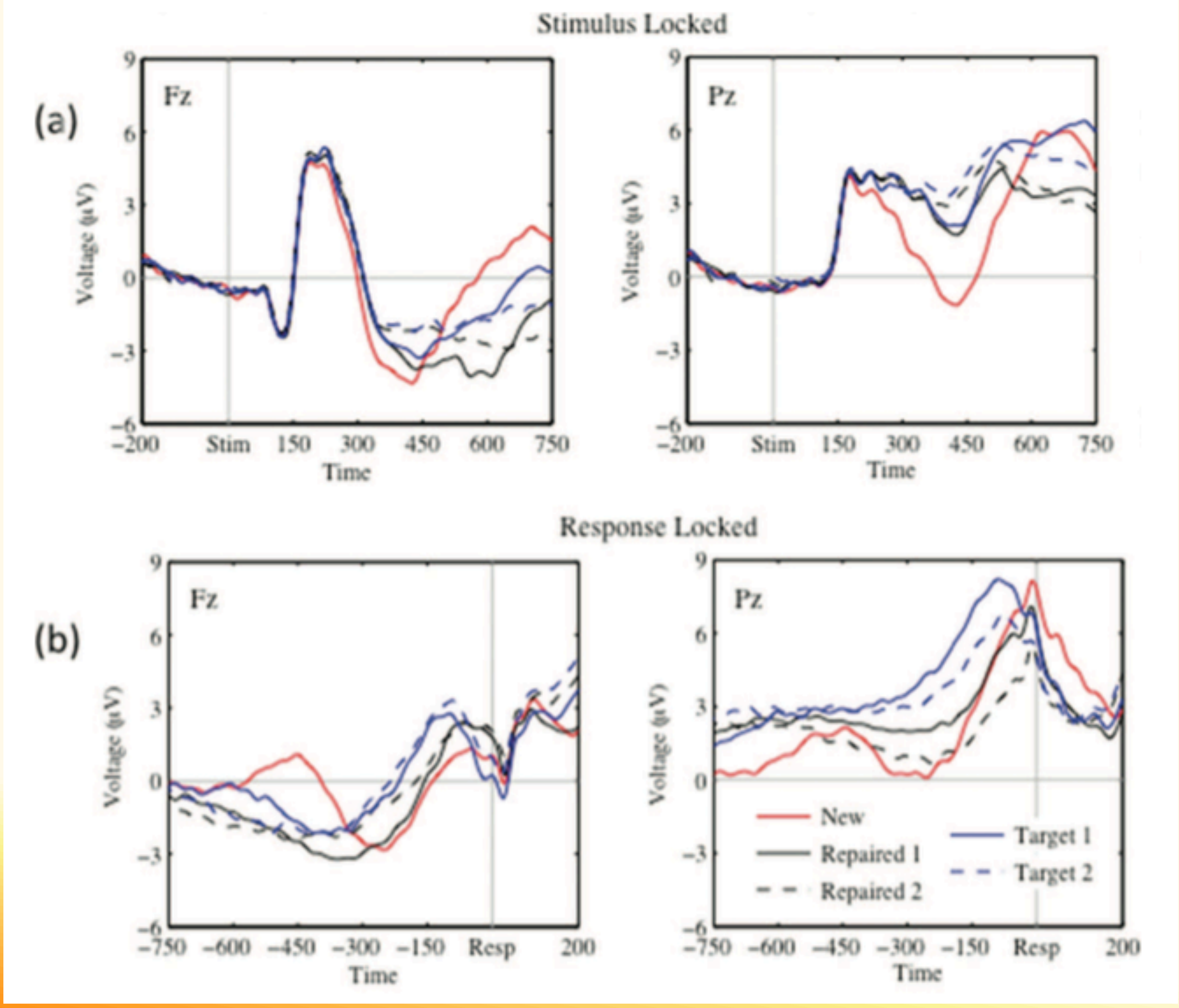
- **Validates theory**
- **But.. We can move beyond it!**
  - **Premise: Bottom-up estimated times correspond with predicted times (i.e., when bottom-up method found a bump before, this aligned well with prediction of when production rule fired)**
  - **Question: Can we**
    - **Measure bumps on individual trials (bottom-up)**
    - **Align bumps (‘warping time’)**
    - **Look at activity at specific EEG components**
  - **Have “bump-related activity” (compared to ERP)**

Paper section “Electrode activity anchored by model events”

“Bump-related activity”



Bump related activity = richer than ERPs (below)



Today’s topics

Process modeling & neuroscience

1. Why do we want to know the details?
2. Why are models useful for neuroscience & why is neuroscience useful for models?
3. What is the associative recognition task? What is the (ACT-R) process model of this task?
4. What can we learn using a “bottom-up” approach (machine learning without theory)?
5. What is the value of combining this with a process model?
6. **What are the seven features of the approach and why are they needed? (page 2-4)**

- **Poster presentations**

7 features of the approach

1. Brain signatures
2. Distributions of state durations
3. Parameter estimation
4. Bottom-up stage identification
5. Process model
6. Linking assumption
7. Increased insight

General discussion

- **Value of approach:**
  - Evaluation / Validation of model: identify stages
  - Ability to match model with EEG (but also fMRI & MEG!)
  - Increased insight
- **Model identifies stages**
- **Still aspects missing:**
  1. What generates the bumps?
  2. Bumps explain only ~5% of variance in EEG
  3. Sustained activity cannot be modeled
     (you need a bump)

Exam material from this lecture

- **All material covered in class**
- **Articles:**
  - **Anderson, J. R., Zhang, Q., Borst, J. P., & Walsh, M. M. (2016). The Discovery of Processing Stages: Extension of Sternberg's Method. *Psychological Review*.**
  - **These sections are *not* mandatory to read:**
    - **Generalization to a Sternberg Working Memory Task**
    - **Text after "Comparison with Borst and Anderson" (general discussion part before it you need to read)**

Study questions: (not bullet proof)

- Why are (process) models useful for neuroscience? And why is neuroscience useful for process models?
- What is the associative recognition task? What is the (ACT-R) process model of this task?
- How can 1 bump be detected /reverse-engineered in an EEG signal?
- How can the optimal number of bumps & flats be selected in a “bottom-up” approach? (and how in an approach with a model added?)
- What are the steps of the “bottom-up” approach?
- What can we learn using a “bottom-up” approach (machine learning without theory)?
- What is the value of combining a theoretical (e.g. ACT-R) (process) model with the bottom-up approach?
- How do these approaches outperform more classic approaches such as standard EEG, ERP, fMRI?
- How would you apply the approach to another technique such as fMRI?
- What are the seven features of the approach and why is each feature needed? (page 2-4)

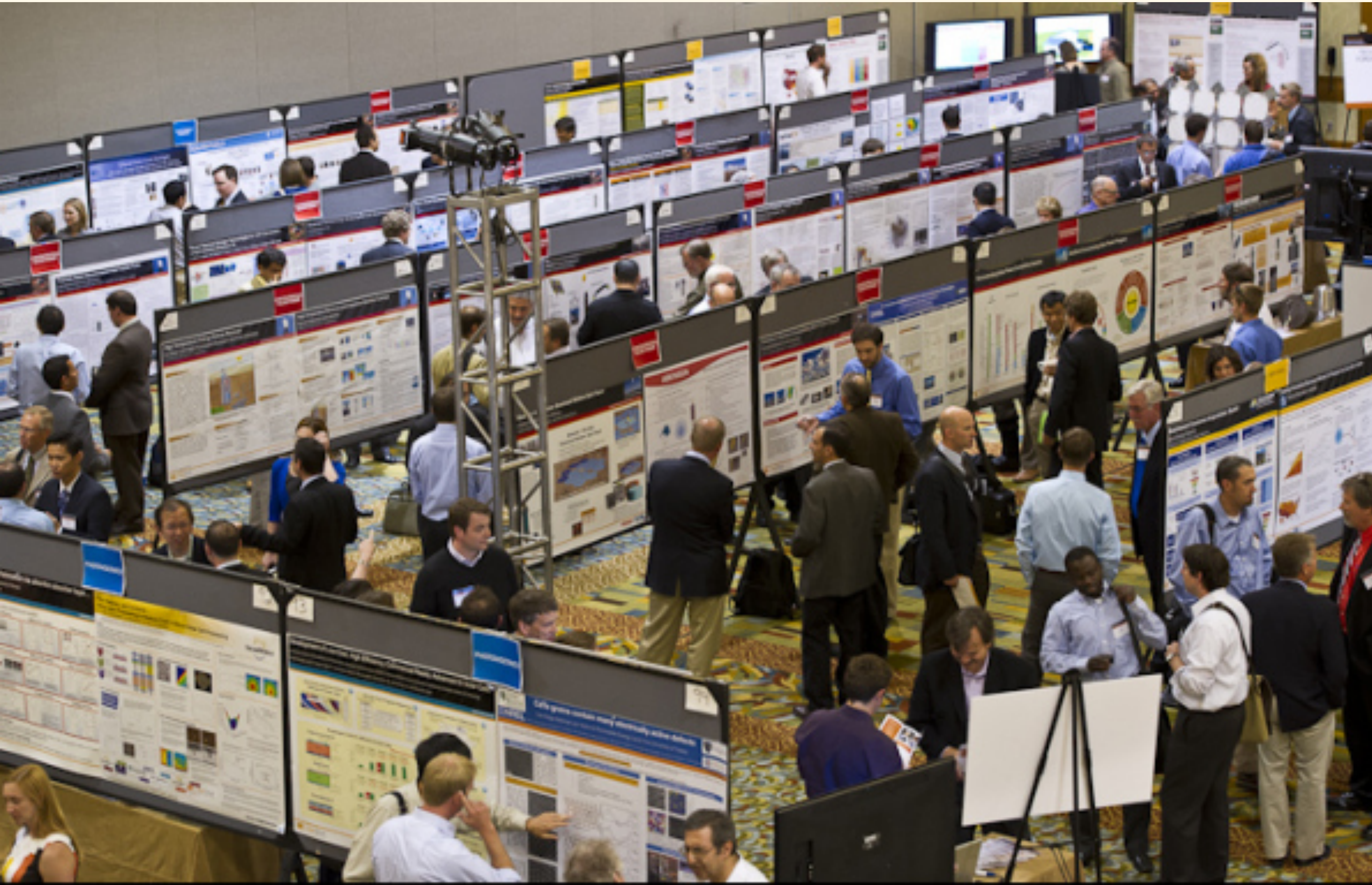
- Be able to apply this to case studies as well

Today's topics

Process modeling & neuroscience

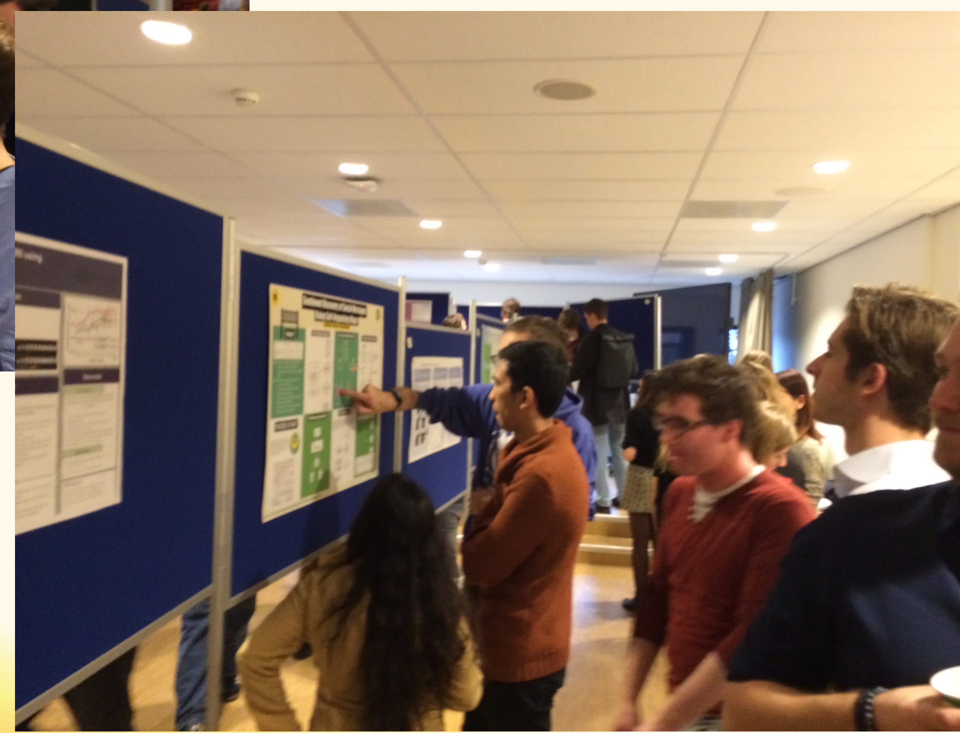
1. Why do we want to know the details?
2. Why are models useful for neuroscience & why is neuroscience useful for models?
3. What is the associative recognition task? What is the (ACT-R) process model of this task?
4. What can we learn using a "bottom-up" approach (machine learning without theory)?
5. What is the value of combining this with a process model?
6. What are the seven features of the approach and why are they needed? (page 2-4)

- **Poster presentations**



Dennis Schroeder/NREL via flickr.com. Public domain (US government agency)

Last year



First things first…

- Read the (appendix of) syllabus
  - Many requirements and details listed there

- Plan ahead to avoid conflicts with other deadlines, such as:
  - Deadline lab assignments
  - Deadlines as discussant
  - Other courses

Posters: goal

- Convey a clear message
- Conversation starter
- Dialogue NOT monologue/lecture

- (sometimes:
  opportunity to pitch other papers
  get people to visit your website, ….)

Posters: context

- Many, many, many other posters
- People also want to see other posters: limited time
- Lighting conditions not always great
- Sometimes: posters shown without author present
  - Those require more text. But otherwise… go light on the amount of text..
- Often on “work in progress”
  - Opportunity to ask peers for feedback
    (what might they criticize during the review process?)
  - Their input is (also) essential

Poster: Implications

- Have something to talk about ("short pitch"); not (only) something "to be read"
- Think about how poster stands out from rest
- Be selective in what you present
- Have visuals, make them readable; not a lot of text
  - Large lines, fonts, etc
  - For this course: feel free to "redraw" approximate graph
- During design: Think about what the story is that you tell. How does the poster *support* the story?

Some examples (from my own work)

- **Caveats:**
  - Not all “perfect” in every aspect
  - Can definitely be done differently
  - Give an “impression”

Dual-Task Strategy Adaptation

Christian P. Janssen & Duncan P. Brumby
c.janssen@ucl.ac.uk, d.brumby@cs.ucl.ac.uk

UCL

Case Study
Dialing while Driving

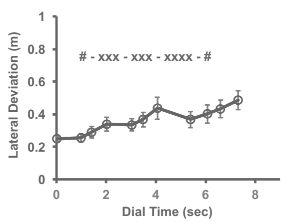
Instructions

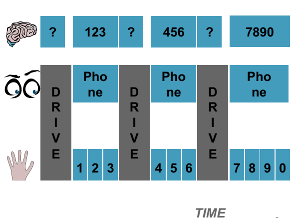
- Task 1: Drive a car (in a simulator)
- Task 2: Dial an 11-digit phone number
- Stay as close to lane centre as possible, while dialing

Typical Results

(Brumby, Salvucci, & Howes, 2009)

- Digits are dialed in groups of 3
- Lateral deviation is corrected between groups … at "breakpoints"





Theoretical Explanation

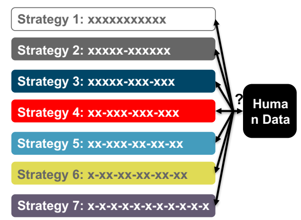
(Salvucci, 2005)

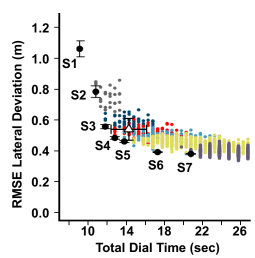
- Memory chunks accord to phonebook structure …US number: groups of 3
- While memory retrieves a chunk.. … eyes can be on the road … hands can steer
- Breakpoints align with chunk boundaries

Research Question
Do breakpoints solely occur at chunk boundaries?

Methodology

- Use a number with 1 chunk boundary: 01953-842761
- Develop a Cognitive Constraint Model to explore the effect of a range of strategies on performance
- Compare model predictions with human data



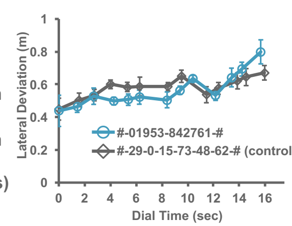


Model Predictions

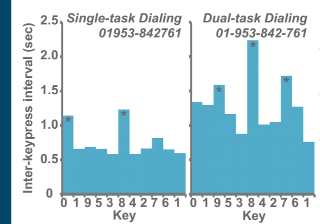
- Interleaving is necessary to stay within lane boundaries (i.e., S2-S7 versus S1)
- Interleaving solely at chunk boundaries (S2) leads to bad performance
- Interleaving 2 to 4 times is quite good (S3, S4, S5)

Empirical Data

- Subjects interleave dialing for driving
- Interleave pattern differs from typical USA number
- Interleave pattern differs from control condition (a number with lots of chunks)



Results
Additional breakpoints are added for interleaving, despite memory costs

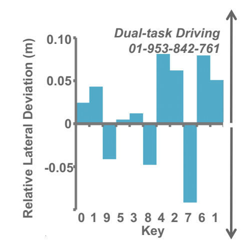


Inter-keypress Intervals

- Increase in dual-task compared to single-task
- Extra increase at chunk boundary
- Surprising extra increase at positions 3 and 9 (halfway through the chunk)

Lateral Deviation

- If left uncorrected, the car drifts away from lane centre
- The car is actively moved towards lane centre at breakpoints



Conclusions

- Secondary task structure can actively be reconfigured to allow for more interleaving
- Dialing is not necessarily interleaved solely at chunk boundaries

References

Brumby, Salvucci, & Howes (2009) Focus on Driving: How Cognitive Constraints Shape the Adaptation of Strategy when Dialing while Driving. *Proceedings of CHI 2009.*

Salvucci, (2005) A Multitasking General Executive for Compound Continuous Tasks. *Cognitive Science, 29*(3)

More Information?

UCL Interaction Centre
Malet Place Engineering Building
Gower Street
London, WC1E 6BT
United Kingdom

c.janssen@ucl.ac.uk
http://www.uclic.ucl.ac.uk/

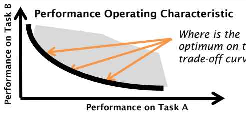
Understanding Strategic Adaptation in Multitask Settings

Christian P. Janssen
University College London
c.janssen@ucl.ac.uk

UCL

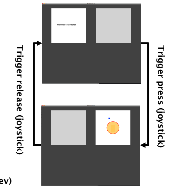
1. Research Question
What is the optimal way to interleave two tasks when multitasking?

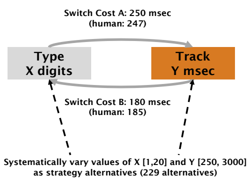
- Behavior adapts to:
  - Instructions *(e.g., Gopher, 1993, Att & Perf XIV)*
  - Priorities *(e.g., Janssen & Brumby, in press, Cog Sci)*
- Performance Operating Characteristic (POC) visualizes curve of multiple optimum trade-offs
  (Norman & Bobrow, 1975, Cogn Psych; Navon & Gopher, 1979, Psych Rev)
- How do people decide how to settle on this curve of optimal dual-task performance?



2. Methodology
Tracking-while-typing task

Experiment
- Instructions:
  - Type 20 digits as fast as possible
  - Keep blue cursor inside yellow target
  - Participant can only control one task at a time
- When should participants switch their attention?
- Manipulations:
  - Within Subjects: Noise of cursor & target size (i.e., task characteristics)
  - Between Subjects: Pay-off function (i.e., priority)



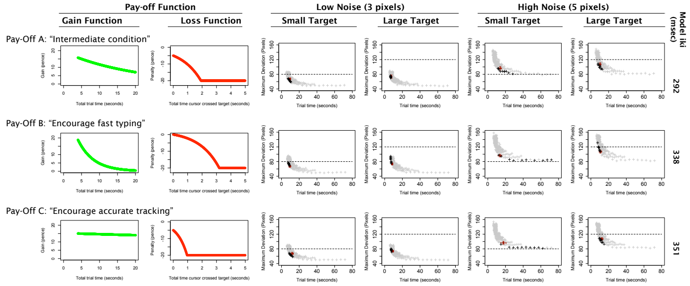


Model
- Modeled using Cognitively Bounded Rational Analysis (Howes, Lewis, & Vera, 2009, Psych Rev)
- Explore performance of alternative strategies & calculate pay-off
- Compare: are humans applying optimum strategy (with highest pay-off)?

3. Results
The optimal region of the trade-off curve changes with condition. Participants mostly apply the optimum strategy.

Model Data
- Performance of different strategies was assessed (grey crosses)
- Pay-Off = Average (Gain + Loss)
- Top 10 strategies are highlighted (black crosses)
- Optimum region lies on trade-off curve
- Different parts of trade-off curve are optimal in different conditions

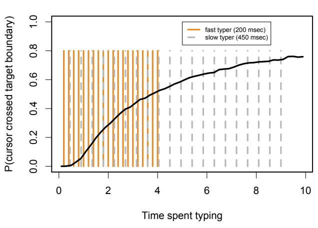
Model & Human Data
- Behavior adapts to:
  - Task characteristics (columns): Noise of cursor & target size
  - Pay-off function (rows)
- Human performance (red dot) mostly lies in optimum region (black crosses)



4. Conclusion and Future Work
This method provides a way to compare performance of different strategies and to identify the optimum region on a POC.

Conclusion
- Behavior adapts to task characteristics and pay-off function
- The optimal region on a trade-off curve (or POC) differs per condition
- This region can only be identified with a model that includes a pay-off function and that explores strategy alternatives (i.e., a cognitively bounded rational analysis model)

Future Work
- Individual differences (e.g., typing speed, see picture on right)
- Learning:
  - Is a systematic pattern followed?
  - Can (reinforcement) learning models predict this? *(e.g., Erev & Gopher, 1999, Att & Perf XVII)*
- Finer grained level of analysis
  e.g., eye-tracking data *(e.g., Hornof, Zhang & Halverson, 2010, CHI)*



Acknowledgements
- This research is sponsored by EPSRC grant EP/G043507/1
- I would like to thank my advisors Duncan Brumby, John Dowell and Nick Chater for their support and advice

EPSRC
Engineering and Physical Sciences Research Council

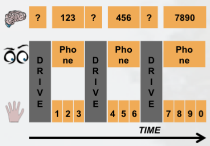
Stop Dialing!

Christian P. Janssen & Duncan P. Brumby

UCL Interaction Centre
http://www.uclic.ucl.ac.uk/people/c.janssen
c.janssen@ucl.ac.uk, d.brumby@cs.ucl.ac.uk

1. Introduction
Toward safer multitasking

Background
- In-car mobile phone use in the UK increased after legislation banned it *(Diels, et al., 2009)*
- Can phones be made less distracting?
- We investigate the theoretical underpinnings of multitasking

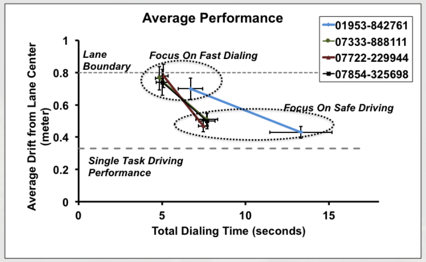


Previous work
(Salvucci, 2005)
- Dialing a phone number while driving
- While memory retrieves part of the number..
  … eyes can be on the road
  … hands can steer
- "Natural Breakpoints": drive when there is an opportunity. Here, when the mind is busy

Research Questions
- What happens when there are only two groups of digits, as in a typical UK number: 12345 – 678901
- Can task prioritization influence behavior?
- Can non-memory related factors also offer natural breakpoints?

Experiment
- Task 1: Drive a car (in a simulator)
- Task 2: Dial an 11-digit phone number
- Keep the car as close to lane centre as possible, while dialing
- Prioritize Safe Driving or Prioritize Fast Dialing

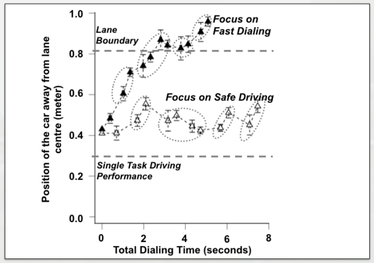
2. General Performance
Task priority determines driving performance



Results for several numbers
- Driving and dialing performance always trade-off
- Best driving performance occurs when the focus is on safe driving
- Risky driving performance occurs when the focus is on fast dialing
- Average driving performance is similar across different phone numbers for each priority setting
- Numbers of which the digits are further apart on the phone (01953 - 842761) take longer to dial, but driving performance stays similar
- It is safest to not dial at all (i.e., single task driving performance)

3. Performance While Driving
Task structure influences task switching

Results for # - 07722 - 229944
- Points indicate individual key presses
- Steering corrections are made between groups of repeating digits (i.e., between ellipses), rather than while typing repeating digits (i.e., within ellipses).
- Having repeating digits provides a different type of natural breakpoint: driving is done at places where the hand already needs to move to find a new digit on the phone
- Steering is mostly effective when the focus is on safe driving
- When the focus is on fast dialing, patterns of breakpoints are present, but not effective: too little time is dedicated to steering



4. Conclusions & Implications
Be aware of your behavior

Conclusions
- Driving and dialing performance trade-off
- Task structure influences performance but only when the right priorities are set
- When the priority is to drive safely, people will interleave at natural breakpoints

Implications
- Public safety campaigns are important:
  - ✓ Driving is safest without dialing
  - ✓ Dual-task performance is best when safe driving is prioritized
- To design safer in-car devices:
  - ✓ Incorporate natural breakpoints
  - ✓ This is only useful for drivers who prioritize safe driving

Future work
- Test generality of findings
- Formalize findings in computational simulations (cognitive models)

References

- Diels, Reed, & Weaver (2009) *Drivers' attitudes to distraction and other motorists' behaviour.* TRL Limited
- Salvucci (2005) A Multitasking General Executive for Compound Continuous Tasks. *Cognitive Science*, 29(3)

Acknowledgements

- This work was supported by EPSRC grant EP/G043507/1
- Thanks to Rae Garnett for collecting part of the data, and to Nick Chater, John Dowell and Justin Grace for feedback on the work

Model Predictions of Reward Optimization in Discrete Dual-Task Scenarios

Chris Janssen, Emma Everaert, Heleen Hendriksen, Ghislaine Mensing, Laura Tigchelaar, Veere Weermeijer, Hendrik Nunner

Utrecht University, Dep. Experimental Psychology, Helmholtz Institute
c.p.janssen@uu.nl
www.cpjanssen.nl

Universiteit Utrecht
Helmholtz Instituut

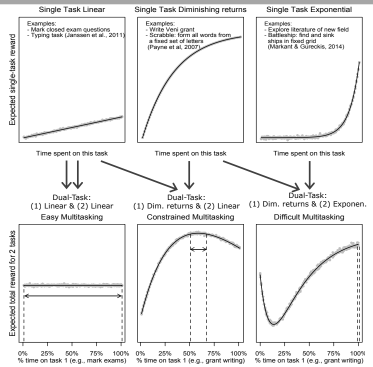
Research question: How do reward functions dictate how we divide time between tasks?
Do people divide their time to maximize their rewards across multiple tasks?

Background: Little is known about efficiency of task switching

- Multitasking and task switching happens in many situations *(Janssen et al., 2015, IJHCS)* e.g., office workers switch every 2-3 minutes *(e.g.,Dabbish, Mark, González, 2011, CHI).*
- How efficient is this? Previous research looked at:
  - Dual-task decrements and contrasting groups (e.g., men vs women; older vs younger)
- Most studies lack a model prediction:
  - What was, in principle, the best possible performance?
  - Could participants have done better than they did?
- Research question: How does efficiency depend on the reward functions of the tasks?

Theoretical model: How rewards affect interleaving strategy

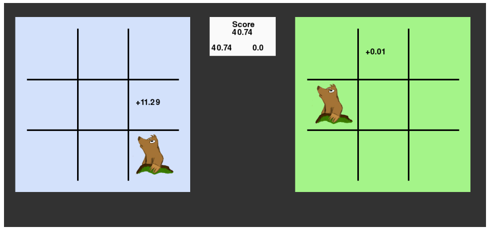
- Choice of interleaving strategy is affected by aspects of
  - Person
  - Ecology and environment
  - Reward functions
    (e.g., Janssen & Brumby, 2015, Plos One; Lewis, Howes, Singh, 2014 Topics, Howes, Lewis, Vera, 2009 Psych Review)
- Rewards have received relatively little attention in the literature *(e.g., Payne et al. 2007, JEP: Gen; Janssen et al. 2011, Topics; Janssen & Brumby 2015, Plos One; Farmer et al., 2017 CogSci)*
- Top figures: Reward functions can differ between tasks
- Bottom figures: The combined reward (vertical axis) fluctuates based on the time division between tasks (horizontal axis) and what tasks are combined (three plots). Optimum range (arrows, dashed lines) is sometimes easy (left), constrained (middle), or hard (right).



Experimental paradigm: Divide time between two identical tasks that have different reward functions
Does time division change when reward function changes? When is optimum score (not) reached?

Hit the mole task

- Hit moles in 9 x 9 grid by pressing numeric key
- Each hit gives points following specific reward function
- Only 1 task visible at a time, switch by pressing space
- Task ends after 50 moles are hit in total across tasks, or time limit
- Full feedback on performance
- Model can predict score for various time divisions



Manipulation: Reward function (within-participants)

- Easy: linear + linear reward
- Difficult: diminishing + exponential reward
- Constrained: diminishing + linear reward

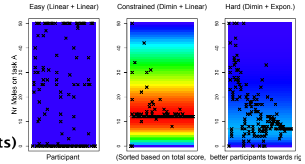
Research question

Is division of time affected by reward functions as predicted by model?

Results and Conclusion: Reward condition changes time division and ability to optimize performance
Implication: whether 'optimality' is observed in a dual-task study depends on the reward functions

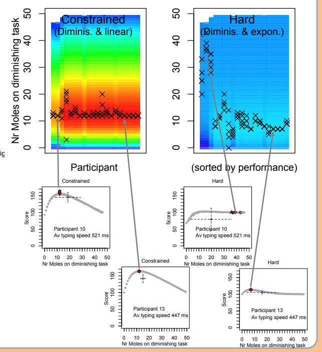
Experiment 1: no time limit (left plots)

- Plots show heatmap of model predictions for score, based on time division between tasks, with human data on last 5 trials (X)
- Reward functions dictate:
  - whether optimum score is easy to achieve
  - how consistent optimum strategy is used
- Constrained scenario is best to test optimality



Experiment 3: time limit of 25 sec (right plots)

- General pattern persists
- Location of optimum depends on (typing) skill
- This changes payoff function (see also bottom for individual plots)
- Performance improves with experience (blue: first 5 trials, red and symbols: last 5 trials)



	Score optimal? (in warmest color)	Variation in time division		Explanation
		Within SJ	Between SJ	
Easy	yes	high	high	No consistency needed
Hard	no	high	high	More learning needed
Constrained	yes	low	low	Clear learned optimum consistently applied

Funding

H2020-MSCA-IF-2015, 705010, 'Detect and React'

MARIE CURIE ACTIONS
HORIZON 2020

Some examples by others

- (Based on slides by Krista Overvliet)

Retinotopic representation of binocular stimuli in early visual cortex

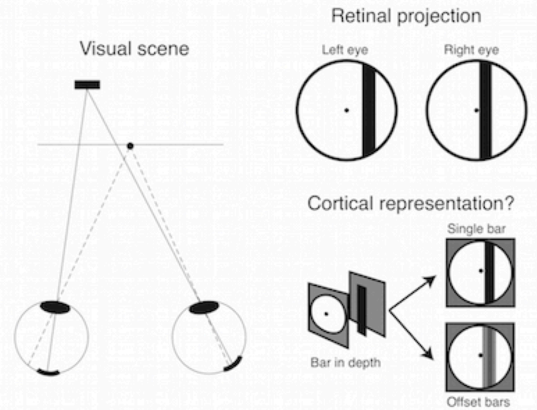
Martijn Barendregt[1,2], Bas Rokers[2] & Serge O. Dumoulin[1]

[1] Helmholtz Institute, Utrecht University, Utrecht, The Netherlands, [2] University of Wisconsin-Madison, Madison, Wisconsin, USA

4180

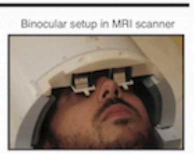
Background

The vast majority of time our two eyes receive different visual input. The visual system combines the two retinal images into a single percept. Does the cortical representation of the visual stimuli reflect the retinal or the perceived position?

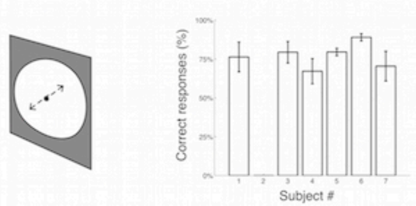


Methods

7 naive observers (1 female) participated. MRI data was acquired on a Philips 7 Tesla scanner using a 1.5s TR and a 2mm isotropic voxel size.

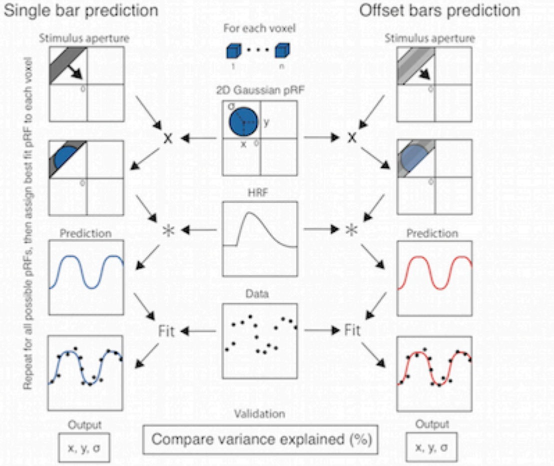


Observers performed a task at fixation. They detected changes in position of the fixation dot in depth and identified the direction of the change (toward/away) to control for attention and verify proper fusion.



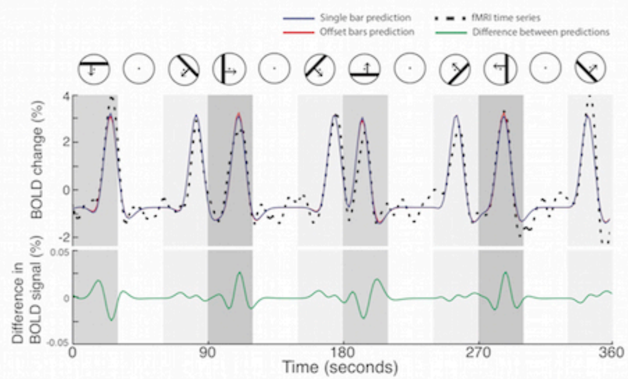
Population receptive field mapping

We estimated the population receptive field (pRF) for each voxel so that the convolution of the stimulus with the pRF predicted the observed BOLD response [1,2].



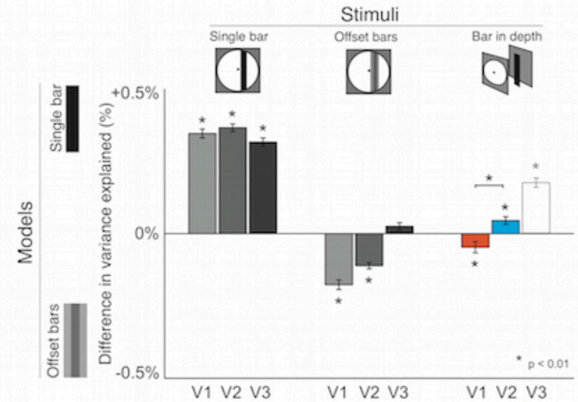
Time series & pRF fit

Example of V1 voxel time series for the 'Offset bars' stimulus and pRF model fit for a single bar model ($R^2 = 88.63\%$) and an offset bar model ($R^2 = 89.19\%$).

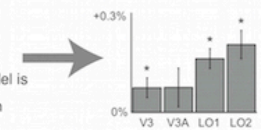


Model-based analysis

We compared the two pRF models by subtracting the amount of variance the models explain for data acquired with the three different stimuli: a single bar, two offset bars and a single bar in depth.



If we only include voxels that correctly discriminate between single and offset bar stimuli, we find that the single bar model is significantly better at explaining the data in areas beyond V2.



Conclusions

In V1 the cortical representation reflects the retinal position of the visual stimuli.

The cortical representation in extrastriate cortex reflects the perceived position of the stimuli.

Acknowledgements

1. Dumoulin & Wandell (2008) *NeuroImage*, 39, 647-660
2. Zuiderbaan, Harvey & Dumoulin (2012) *Journal of Vision*, 12 (3), 10

This work was supported by NWO grant #406-11-197 to MB, NWO #451-09-030 to BR and NWO #452-08-008 to SOD.

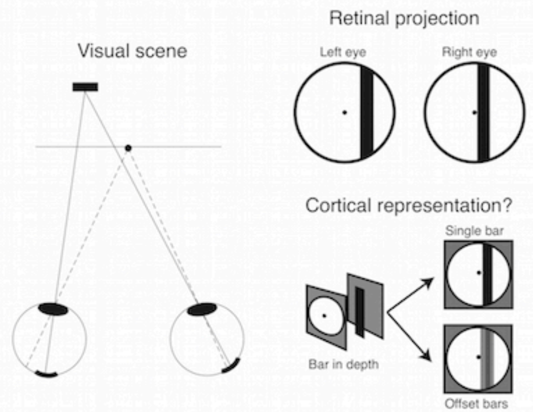
Retinotopic representation of binocular stimuli in early visual cortex

Martijn Barendregt[1,2], Bas Rokers[2] & Serge O. Dumoulin[1]

[1] Helmholtz Institute, Utrecht University, Utrecht, The Netherlands, [2] University of Wisconsin-Madison, Madison, Wisconsin, USA

Background

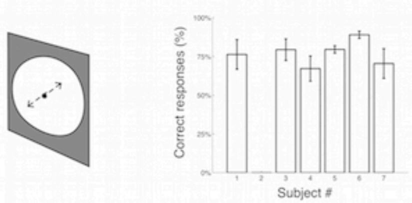
The vast majority of time our two eyes receive different visual input. The visual system combines the two retinal images into a single percept. Does the cortical representation of the visual stimuli reflect the retinal or the perceived position?



Methods

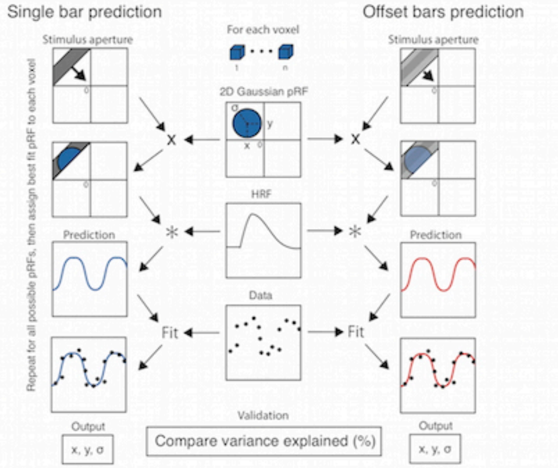
7 naive observers (1 female) participated. MRI data was acquired on a Philips 7 Tesla scanner using a 1.5s TR and a 2mm isotropic voxel size.

Observers performed a task at fixation. They detected changes in position of the fixation dot in depth and identified the direction of the change (toward/away) to control for attention and verify proper fusion.



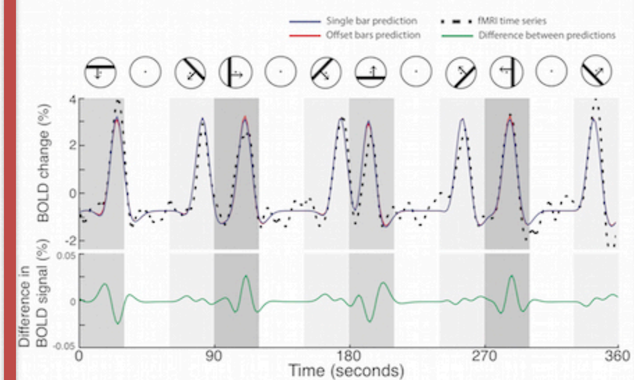
Population receptive field mapping

We estimated the population receptive field (pRF) for each voxel so that the convolution of the stimulus with the pRF predicted the observed BOLD response [1,2].



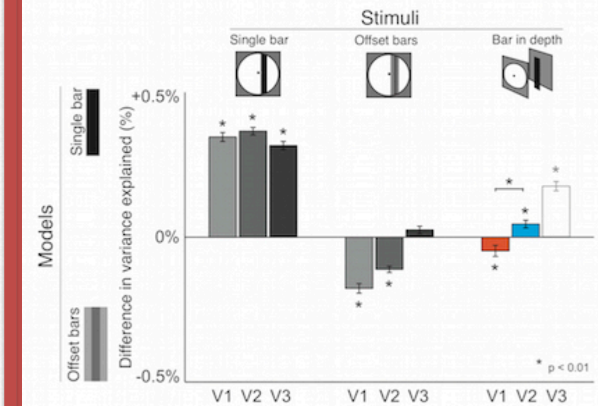
Time series & pRF fit

Example of V1 voxel time series for the 'Offset bars' stimulus and pRF model fit for a single bar model ($R^2 = 88.63\%$) and an offset bar model ($R^2 = 89.19\%$).

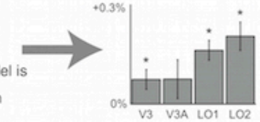


Model-based analysis

We compared the two pRF models by subtracting the amount of variance the models explain for data acquired with the three different stimuli: a single bar, two offset bars and a single bar in depth.



If we only include voxels that correctly discriminate between single and offset bar stimuli, we find that the single bar model is significantly better at explaining the data in areas beyond V2.



Conclusions

In V1 the cortical representation reflects the retinal position of the visual stimuli.

The cortical representation in extrastriate cortex reflects the perceived position of the stimuli.

Acknowledgements

1. Dumoulin & Wandell (2008) *NeuroImage*, 39, 647-660
2. Zuiderbaan, Harvey & Dumoulin (2012) *Journal of Vision*, 12 (3), 10

This work was supported by NWO grant #406-11-197 to MB, NWO #451-09-030 to BR and NWO #452-08-008 to SOD.

Disentangling aspects of vision-guided motor coordination with pupillometry and choline supplementation

Marnix Naber[1-2], Peter Murphy[2], Bernhard Hommel[2], & Lorenza Colzato[2]
[1]Utrecht University, The Netherlands; [2]Leiden University, The Netherlands. Correspondence: marnixnaber@gmail.com

Introduction

The speed-accuracy trade-off is central to effective motor coordination. Sometimes it is required to be fast and in other instances it is better to be accurate. We investigated whether choline (an acetylcholine precursor) can bias the trade-off and whether the pupil can serve as a proxy of this bias.

Experiment 1 - Methods

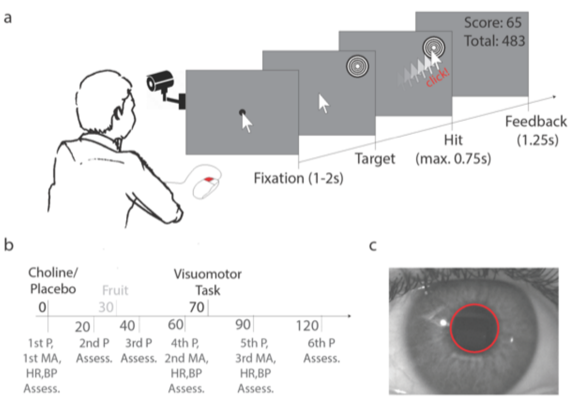
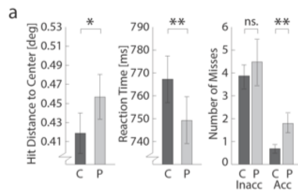


Figure 1. Task, procedure, and pupillometry. (a) Participants used an optical mouse to quickly and accurately move a cursor from fixation to a target's center on the screen. (b) Experimental procedure. Participants performed two sessions, one after 2mg choline ingestion and one after a placebo. (c) Pupillometry was performed with a USB3 camera and automatic pupil detection.

Experiment 1 - Results



Mouse was moved slower but closer to the target and targets were missed less often after choline supplementation. Pupil constricted after choline supplementation. Sizes of choline's effects on behavior correlated with effects on pupil size.

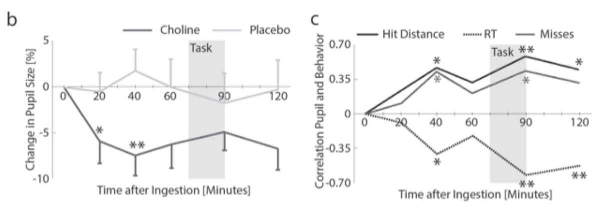


Figure 2. (a) As compared to the placebo condition (light grey), choline ingestion by the participants (dark grey) improved accuracy but slowed responses (C = choline; P = placebo; Inacc = inaccurate, participants with more misses; Acc = accurate, participants with less misses). (b) Participant's pupil sizes decreased as a function of time after choline (dark grey) but not after placebo (light grey) supplementation. (c) Changes in pupil size correlated with accuracy and speed measures across participants.

Experiment 2 - Methods

Same as in experiment 1, except no drugs and different instruction:

1) be as fast as possible (F)

2) be as accurate as possible (A)

3) be both fast and accurate (Trade-Off; TO)

Experiment 2 - Results

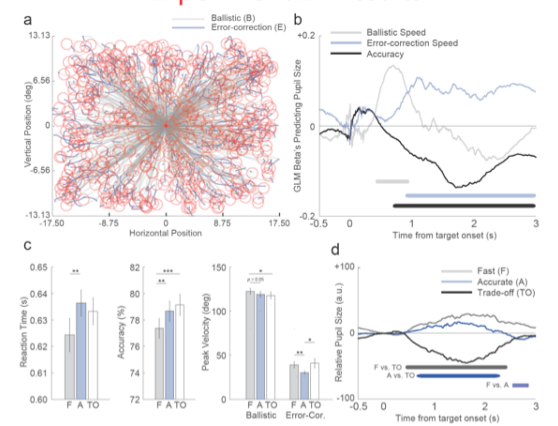


Figure 3. (a) The movement trajectories towards the targets (red) can be divided in a ballistic (grey) and error-correction (blue) sub-movements. (b) General linear model (GLM) beta's of several factors predicting pupil size. Pupil size increases as movement speed increases, pupil size decreases as accuracy increases. (c) Typical reaction time, accuracy, and movement speed patterns as a function of speed-accuracy instructions. (d) Pupil size was smaller when participants were instructed to be accurate, but smallest when instructed to balance speed and accuracy.

Conclusions

Choline biases trade-off towards accuracy and decreases pupil size.

Smaller pupil sizes after accurate movements, independent of instruction

Trade-off instruction cause weaker dilations

Trade-off instruction increases movement speed during error-movement

Can Haptic Search be Parallel? Not When Using Spatial Features to Distinguish between Target and Distractors.

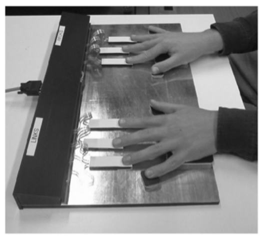
Krista E. Overvliet, Jeroen B.J. Smeets, Eli Brenner

Department of Neuroscience, Erasmus MC, Rotterdam, The Netherlands
K.Overvliet@ErasmusMC.nl

Erasmus MC
University Medical Center Rotterdam

QUESTION

The **Feature Integration Theory of Attention** (Treisman & Gelade, 1980) states that simple features are detected in parallel with no attentional limits, while objects (conjunctions of features) are identified sequentially, at a later stage, using focal attention.
The search for targets defined by simple features should be little affected by variations in the number of items in the display, while the targets defined by a conjunction of features should be found only after a serial scan of the varying number of items.
We wanted to use the theory of Treisman and Gelade to examine whether the same unique spatial features would yield parallel search in the haptic domain as in the visual domain.

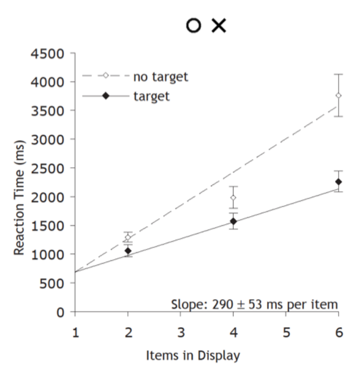


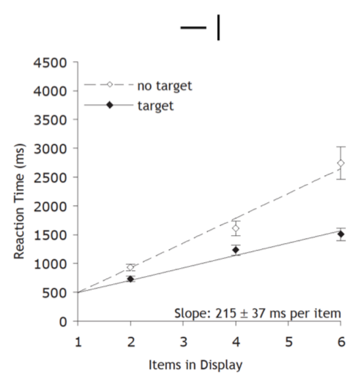
METHOD

We presented haptic line drawings, made of ZY®-TEX2 Swell paper, to the fingertips of both hands of the subjects. The task for the subject was to search for the target between two to six items. They had to lift the finger under which they thought the target was, if they couldn't find a target they had to lift all fingers.

	TARGET	
ITEMS	X	I
6	× o o o o o	— — — — | —
4	o o o ×	| — — —
2	× o	— |

RESULTS





Haptic search functions; Error bars indicate the standard error of the mean (8 subjects). The lines are the result of the fit of a serial search model to both the target present and target absent trials

CONCLUSION

The theory of Treisman and Gelade (1980) doesn't hold in the haptic domain, when using spatial features to distinguish between target and distractors.

Some less good examples

- (Based on slides by Krista Overvliet)

PIGS IN SPACE: EFFECT OF ZERO GRAVITY AND AD LIBITUM FEEDING ON WEIGHT GAIN IN CAVIA PORCELLUS

Colin B. Purrington
6673 College Avenue, Swarthmore, PA 19081 USA

ABSTRACT:

One ignored benefit of space travel is a potential elimination of obesity, a chronic problem for a growing majority in many parts of the world. In theory, when an individual is in a condition of zero gravity, weight is eliminated. Indeed, in space one could conceivably follow ad libitum feeding and never even gain an gram, and the only side effect would be the need to upgrade one's stretchy pants("exercise pants"). But because many diet schemes start as very good theories only to be found to be rather harmful, we tested our predictions with a long-term experiment in a colony of Guinea pigs (Cavia porcellus) maintained on the International Space Station. Individuals were housed separately and given unlimited amounts of high-calorie food pellets. Fresh fruits and vegetables were not available in space so were not offered. Every 30 days, each Guinea pig was weighed. After 5 years, we found that individuals, on average, weighed nothing. In addition to weighing nothing, no weight appeared to be gained over the duration of the protocol. If space continues to be gravity-free, and we believe that assumption is sound, we believe that sending the overweight — and those at risk for overweight — to space would be a lasting cure.

INTRODUCTION:

The current obesity epidemic started in the early 1960s with the invention and proliferation of elastane and related stretchy fibers, which released wearers from the rigid constraints of clothes and permitted monthly weight gain without the need to buy new outfits. Indeed, exercise today for hundreds of million people involve only the act of wearing stretchy pants in public, presumably because the constrictive pressure forces fat molecules to adopt a more compact tertiary structure (Xavier 1965).

Luckily, at the same time that fabrics became stretchy, the race to the moon between the United States and Russia yielded a useful fact: gravity in outer space is minimal to nonexistent. When gravity is zero, objects cease to have weight. Indeed, early astronauts and cosmonauts had to secure themselves to their ships with seat belts and sticky boots. The potential application to weight loss was noted immediately, but at the time travel to space was prohibitively expensive and thus the issue was not seriously pursued. Now, however, multiple companies are developing cheap extra-orbital travel options for normal consumers, and potential travelers are also creating news ways to pay for products and services that they cannot actually afford. Together, these factors open the possibility that moving to space could cure overweight syndrome quickly and permanently for a large number of humans.

We studied this potential by following weight gain in Guinea pigs, known on Earth as fond of ad libitum feeding. Guinea pigs were long envisioned to be the "Guinea pigs" of space research, too, so they seemed like the obvious choice. Studies on humans are of course desirable, but we feel this current study will be critical in acquiring the attention of granting agencies.

MATERIALS AND METHODS:

One hundred male and one hundred female Guinea pigs (Cavia porcellus) were transported to the International Space Laboratory in 2010. Each pig was housed separately and deprived of exercise wheels and fresh fruits and vegetables for 48 months. Each month, pigs were individually weighed by duct-taping them to an electronic balance sensitive to 0.0001 grams. Back on Earth, an identical cohort was similarly maintained and weighed. Data was analyzed by statistics.

RESULTS:

Mean weight of pigs in space was 0.0000 +/- 0.0002 g. Some individuals weighed less than zero, some more, but these variations were due to reaction to the duct tape, we believe, which caused them to be alarmed push briefly against the force plate in the balance. Individuals on the Earth, the control cohort, gained about 240 g/month ($p = 0.0002$). Males and females gained a similar amount of weight on Earth (no main of effect of sex), and size at any point during the study was related to starting size (which was used as a covariate in the ANCOVA). Both Earth and space pigs developed substantial dewlaps (double chins) and were lethargic at the conclusion of the study.

CONCLUSIONS:

Our view that weight and weight gain would be zero in space was confirmed. Although we have not replicated this experiment on larger animals or primates, we are confident that our result would be mirrored in other model organisms. We are currently in the process of obtaining necessary human trial permissions, and should have our planned experiment initiated within 80 years, pending expedited review by local and Federal IRBs.

ACKNOWLEDGEMENTS:

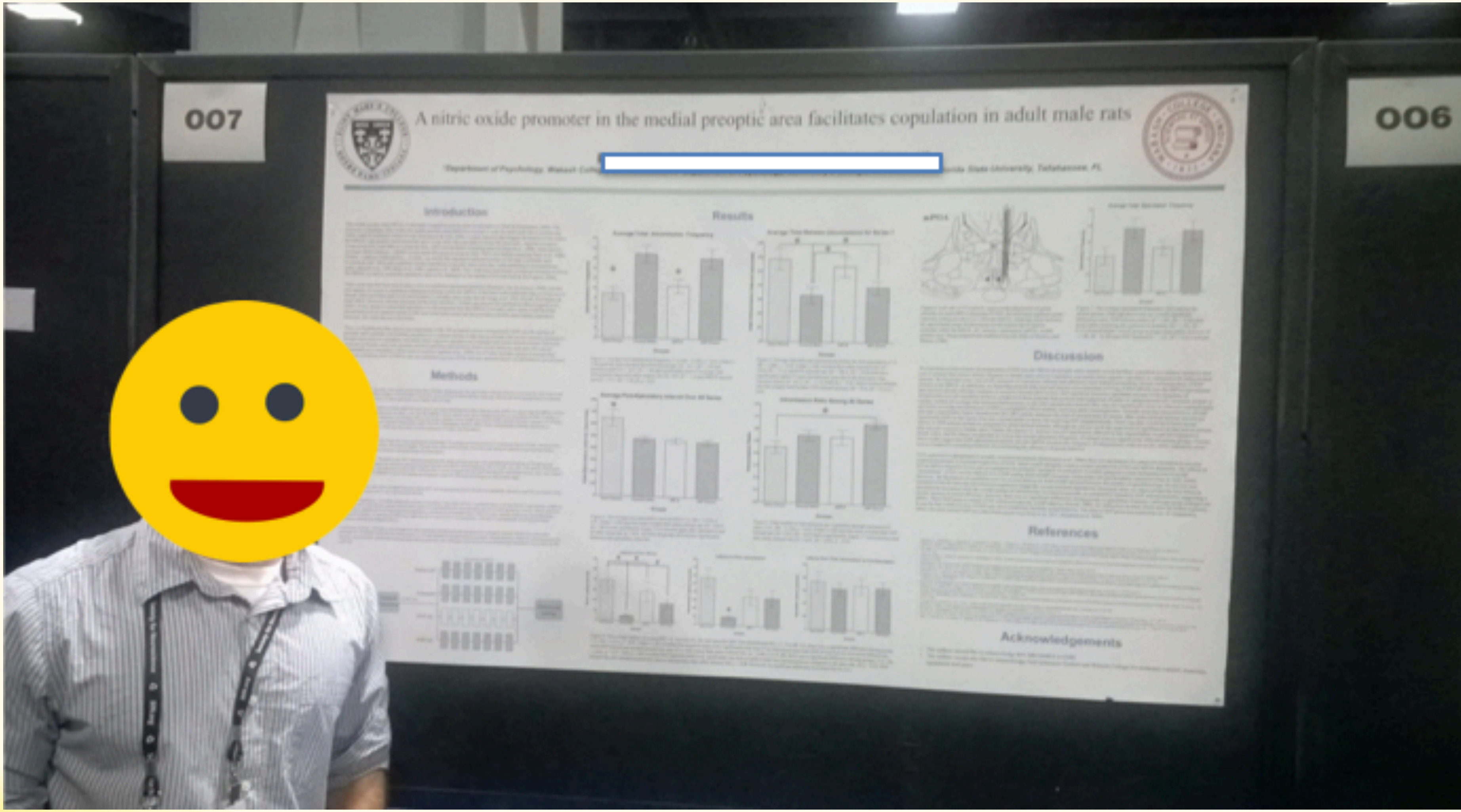
I am grateful for generous support from the National Research Foundation, Black Hole Diet Plans, and the High Fructose Sugar Association. Transport flights were funded by SPACE-EXES, the consortium of wives divorced from insanely wealthy space-flight startups. I am also grateful for comments on early drafts by Mañana Athletic Club, Corpus Christi, USA. Finally, sincere thanks to the Cuy Foundation for generously donating animal care after the conclusion of the study.

LITERATURE CITED:

NASA. 1982. Project STS-XX: Guinea Pigs. Leaked internal memo.

Sekulić, S.R., D. D. Lukač, and N. M. Naumović. 2005. The Fetus Cannot Exercise Like An Astronaut: Gravity Loading Is Necessary For The Physiological Development During Second Half Of Pregnancy. Medical Hypotheses. 64:221-228

Xavier, M. 1965. Elastane Purchases Accelerate Weight Gain In Case-control Study. Journal of Obesity. 2:23-40.


007
006
A nitric oxide promoter in the medial preoptic area facilitates copulation in adult male rats
Introduction
Results
Methods
Discussion
References
Acknowledgements

Conclusion posters

- **Make it appealing**
- **Let it help (instead of take over) the dialogue**
- **Be selective in what you present**
- **Make sure to read the course manual for more detailed tips and requirements**

Scheduling of posters

- You should all have signed up for a group presentation of a paper
- You should all have signed up to be discussant for 3 other posters

- NB: Discussants I might move around a little (after deadline), as they are not always aligned with presentation slots

Coming up

- Friday: computer labs
  - Have R installed
  - Read the assignment up front (lots of reading)
- Next week: Dr. Jakub Dotlačil on processing models in linguistics
  - Read article Croker (1999) up front, as lecturer will build on that information

Questions?

Chris Janssen

c.p.janssen@uu.nl
www.cpjanssen.nl