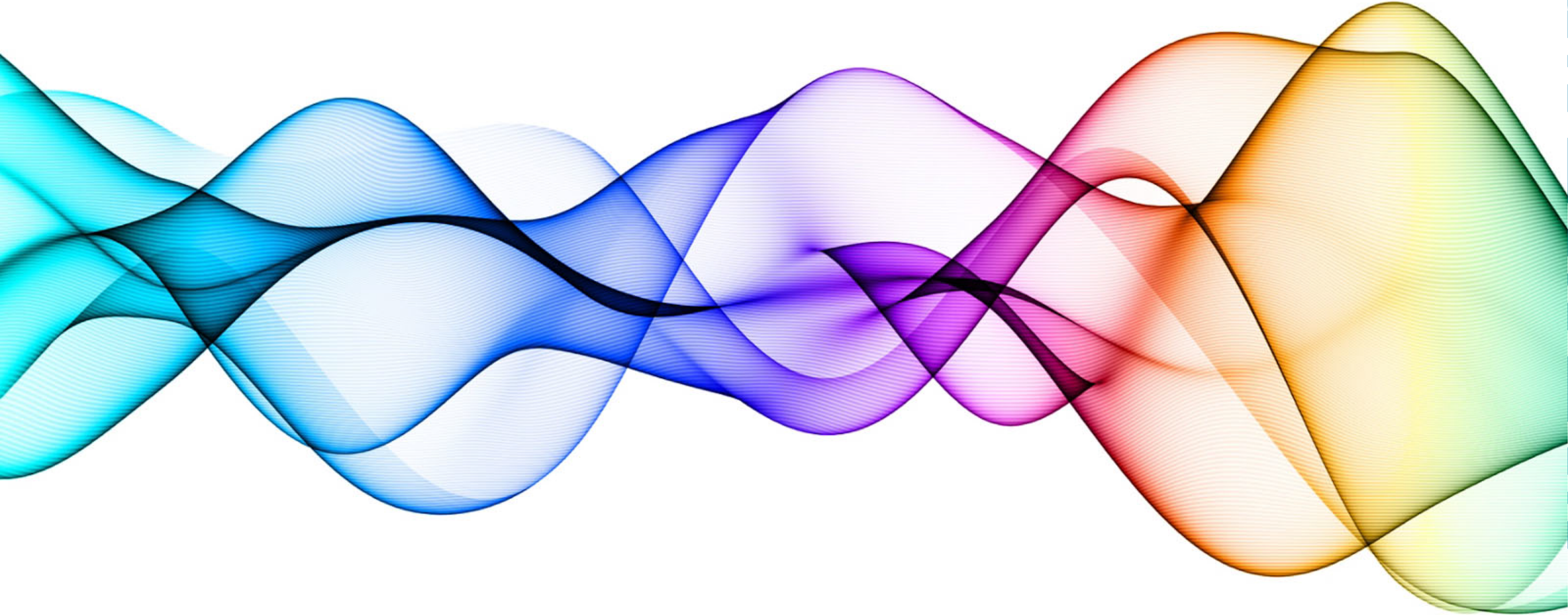

MEMORY OF ERROR

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Seoul National University
Aug 24, 2017

MNE
MEG + EEG ANALYSIS & VISUALIZATION

NIH National Institute of Neurological Disorders and Stroke

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   - Goal of the study
   - Experimental Design

Goal of the study

ERROR MEMORY

Practice makes perfect – or does it?

How do we learn from past errors? Herzfeld *et al.* found that when we practice a movement, the human brain has a memory for errors that is then used to learn faster in new conditions. This memory for error exists in parallel with motor memory's two traditional forms: memory of actions and memory of external perturbations. They also proposed a mathematical model for learning from errors. This model explained previous experimental results and predicted other major findings that they later verified experimentally. — PRS

ERROR MEMORY

Science

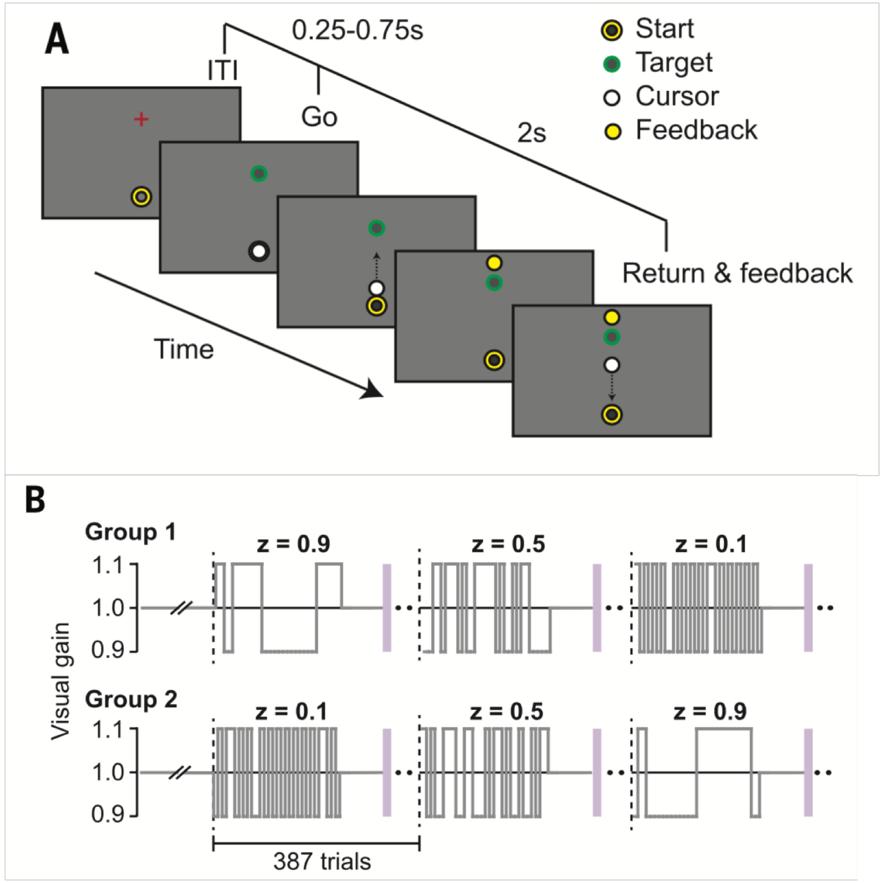
A memory of errors in sensorimotor learning

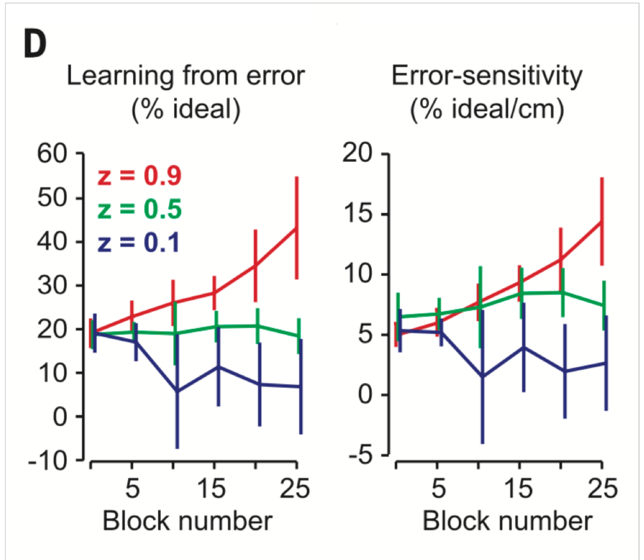
David J. Herzfeld,[1*] Pavan A. Vaswani,[2] Mollie K. Marko,[1] Reza Shadmehr[1]

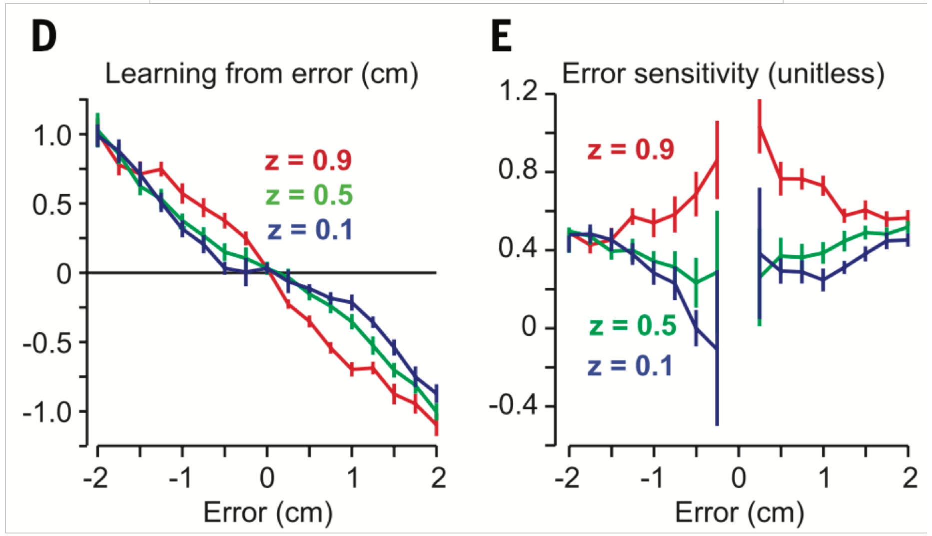
The current view of motor learning suggests that when we revisit a task, the brain recalls the motor commands it previously learned. In this view, motor memory is a memory of motor commands, acquired through trial-and-error and reinforcement. Here we show that the brain controls how much it is willing to learn from the current error through a principled mechanism that depends on the history of past errors. This suggests that the brain stores a previously unknown form of memory, a memory of errors. A mathematical formulation of this idea provides insights into a host of puzzling experimental data, including savings and meta-learning, demonstrating that when we are better at a motor task, it is partly because the brain recognizes the errors it experienced before.

Science **345** (6202), 1349-1353.
DOI: 10.1126/science.1253138originally published online August 14, 2014

Goal of the study







Goal of the study

1. Does the brain remember the error you make?

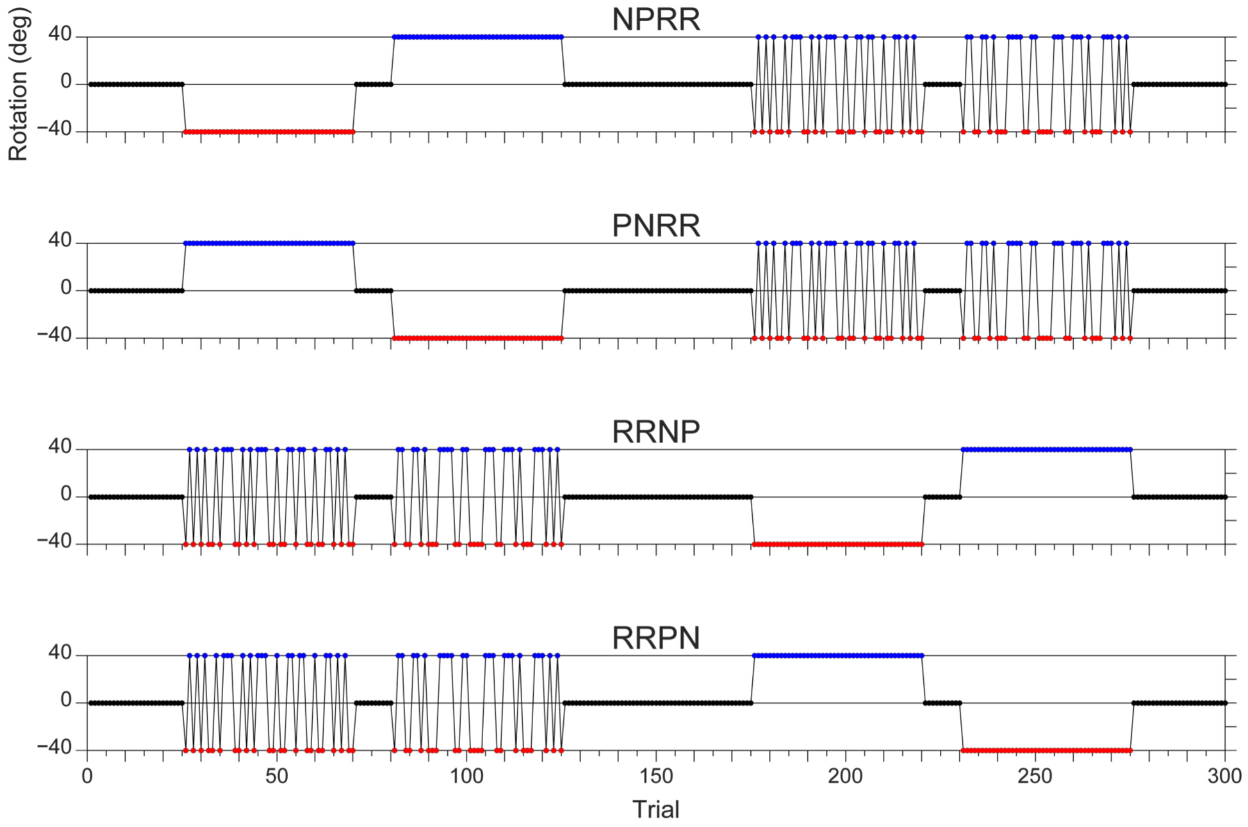
2. How long & how strong are they maintained?

Visuomotor adaptation learning

Visuomotor adaptation learning

Experimental Design

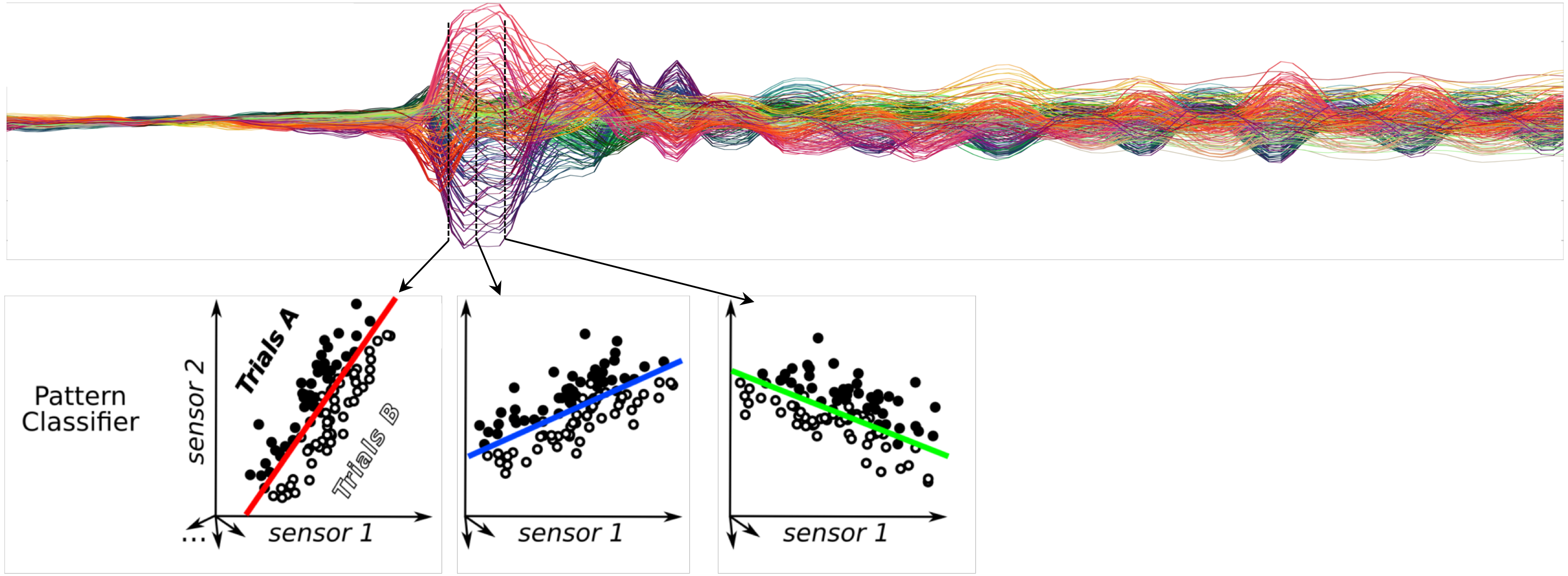
300 trials



MVPA Decoding

1. Brain activity is recorded by MEG
2. Multivariate Pattern Analysis (MVPA)

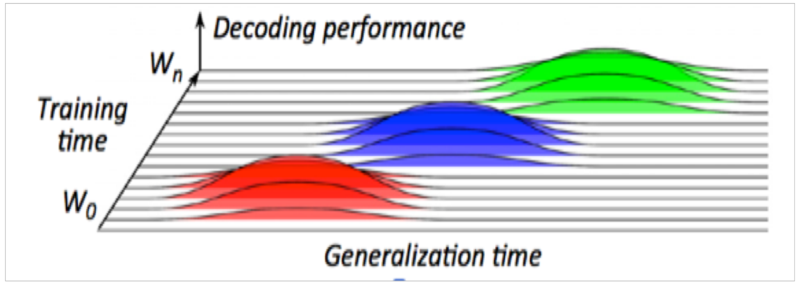
An estimator is trained at each time point to separate MEG activity distributions associated with content and rule

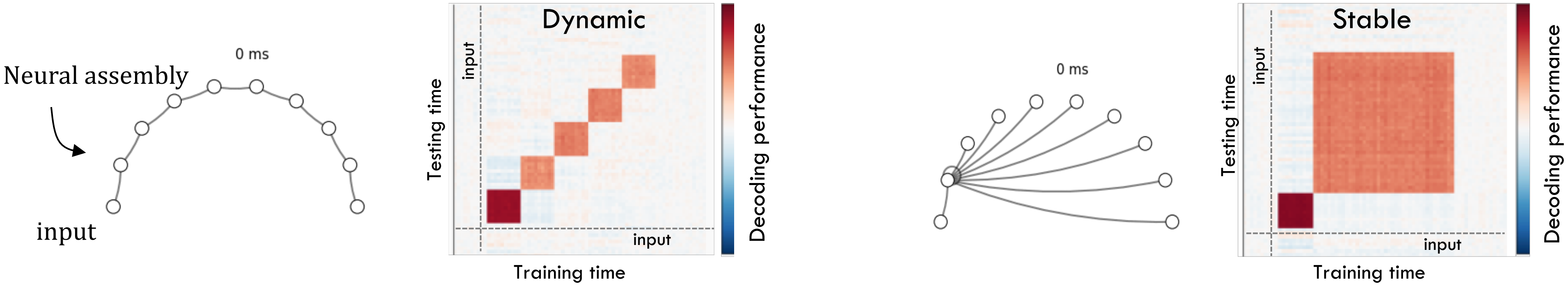


GAT Method

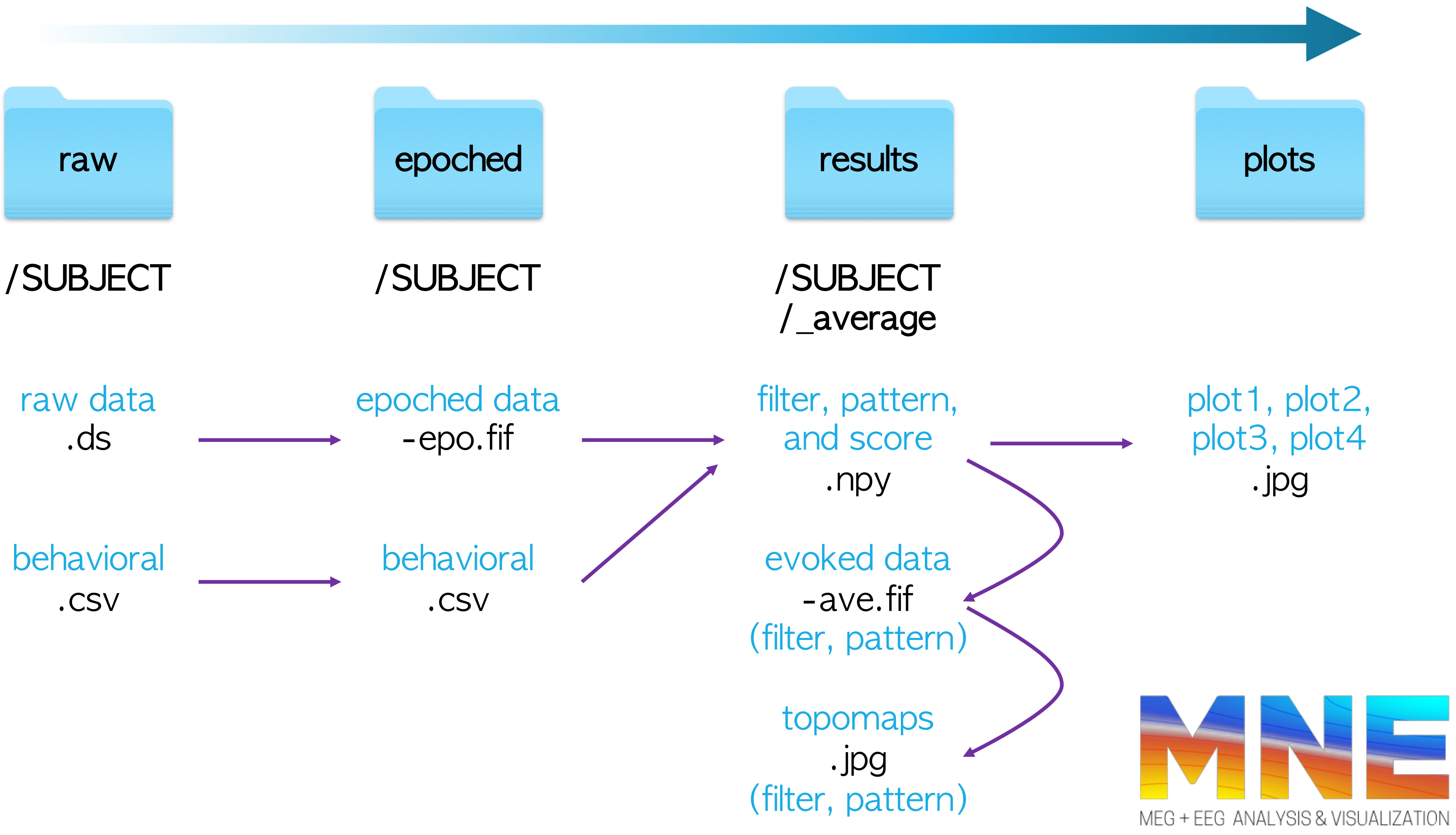
3. Generalization across time (GAT)

Each estimator is tested on its ability to generalize to all time points





King and Dehaene. 2014



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plot3, plot4
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behavioral
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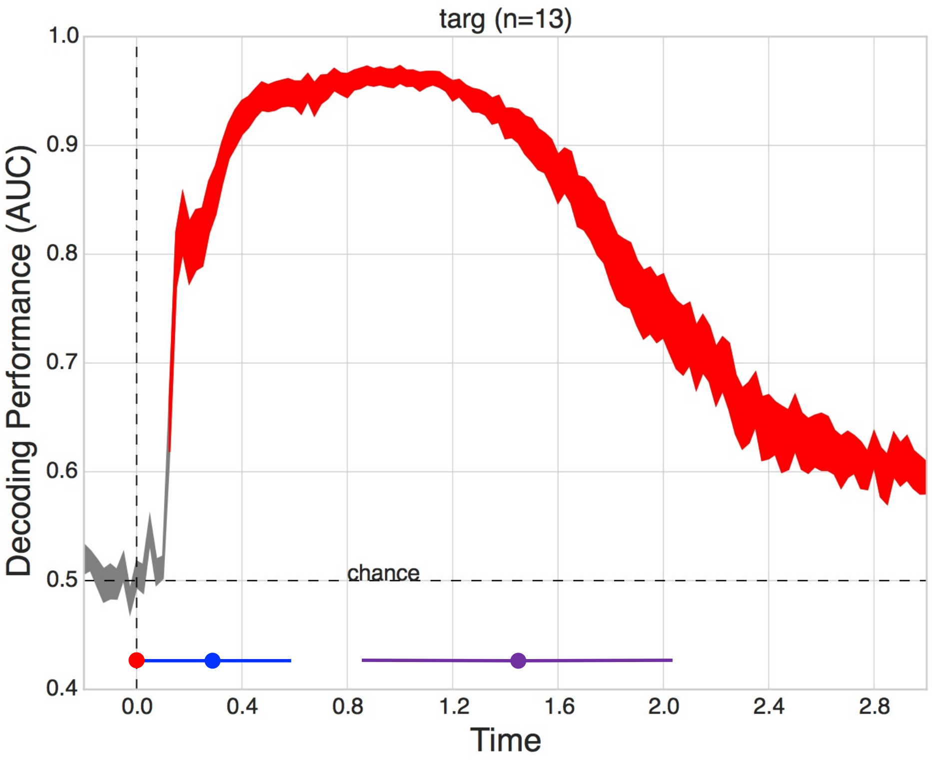
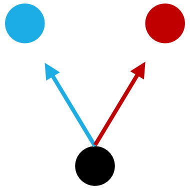
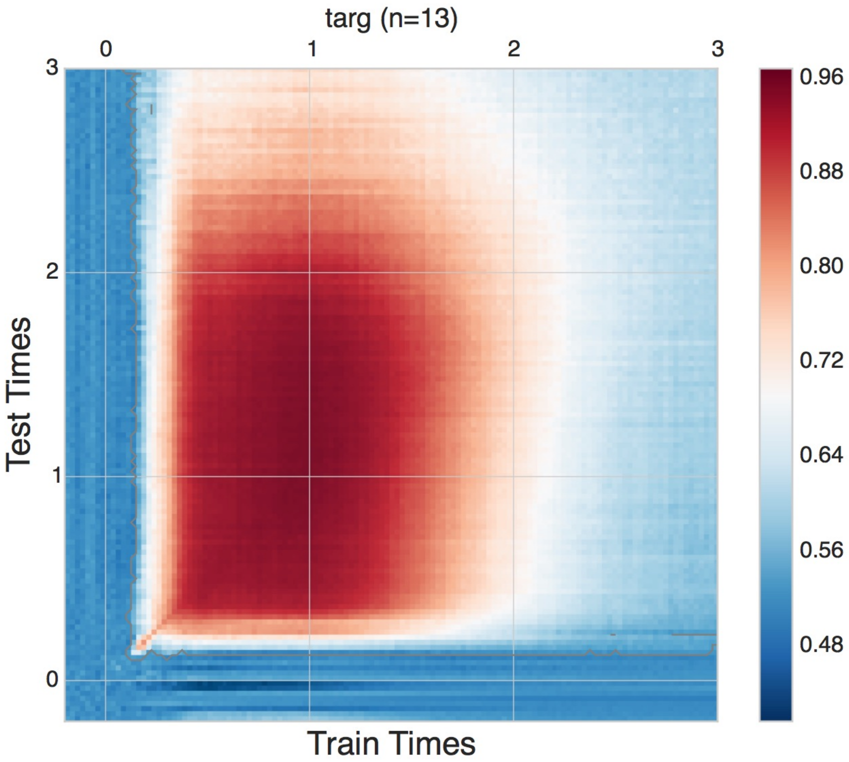
topomaps
.jpg
(filter, pattern)
MEG + EEG ANALYSIS & VISUALIZATION

Decoding *Target Position*

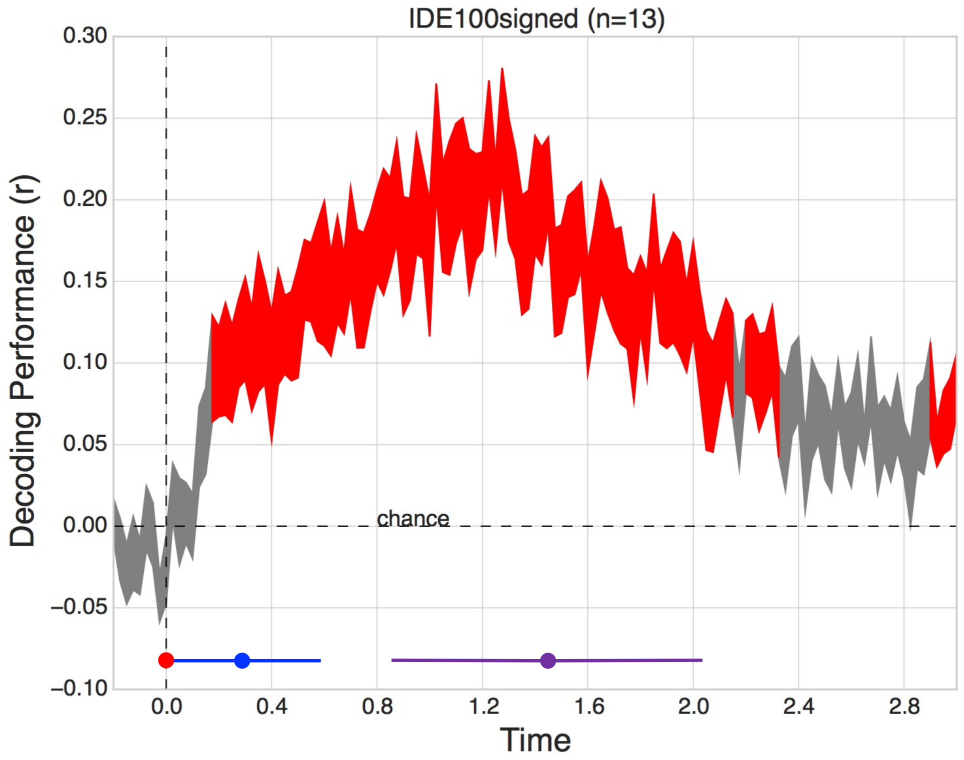


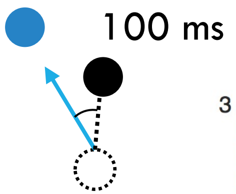


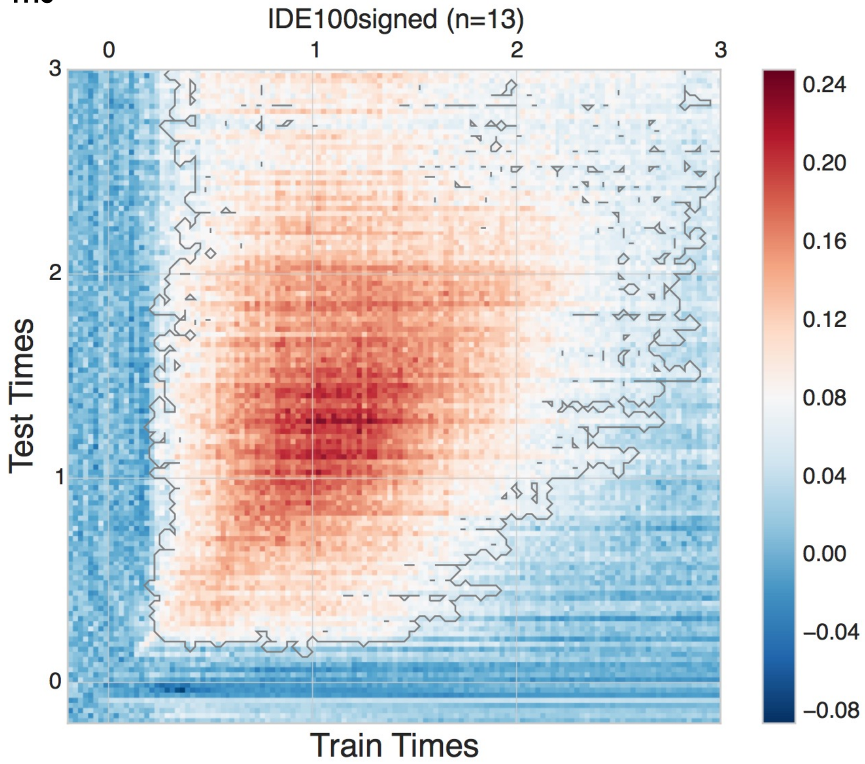


- Target appears
- Movement starts
- Contacts target

Decoding *Directional Error at 100 ms*

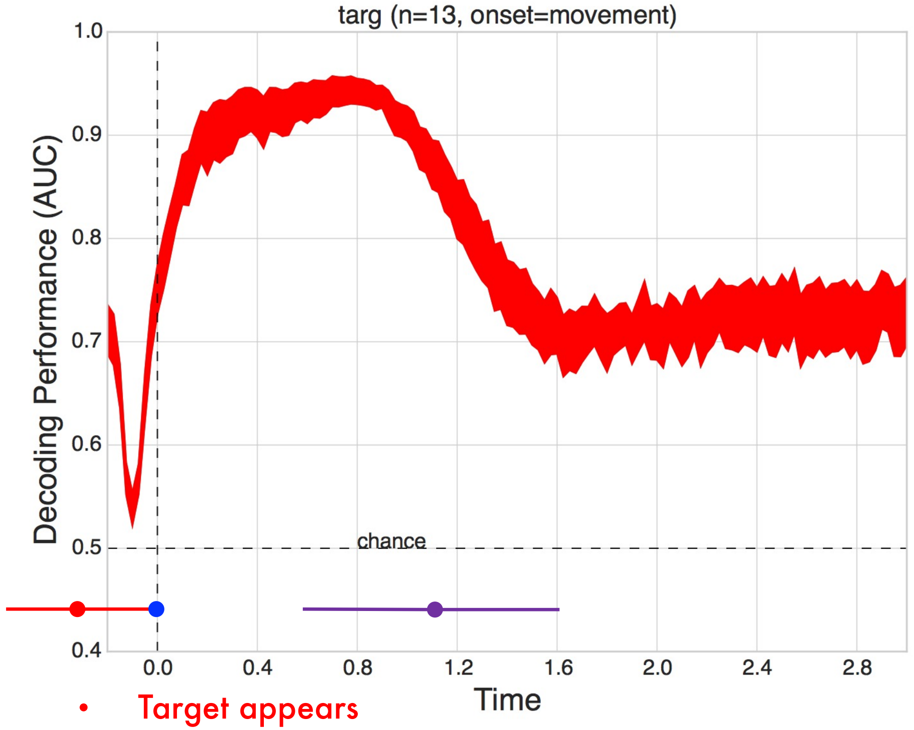






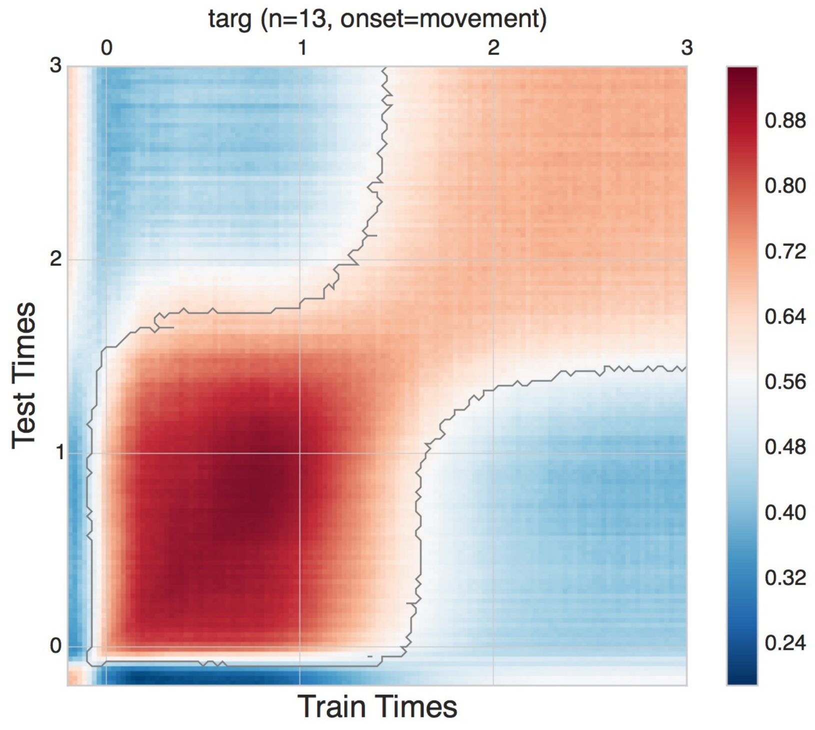
- Target appears
- Movement starts
- Contacts target

Time-locking the Movement Onset (targ)



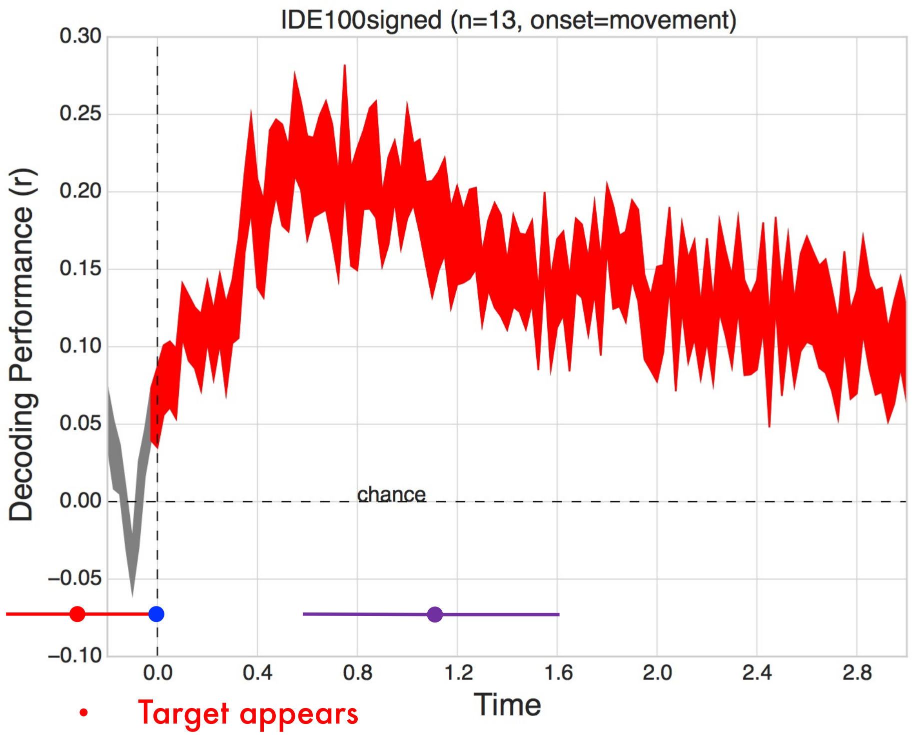
- Target appears
- Movement starts
- Contacts target

Second activation = coming back?

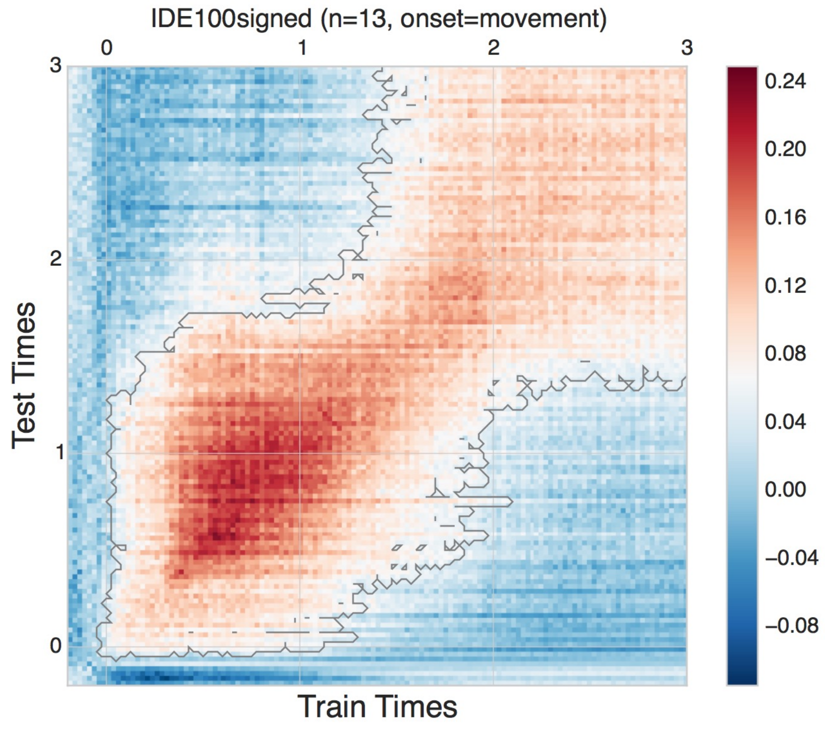


Time-locking the Movement Onset (IDE 100ms)

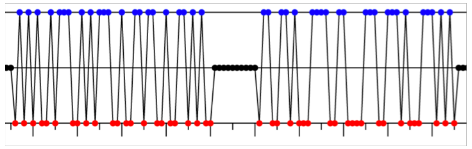
Second activation = coming back?



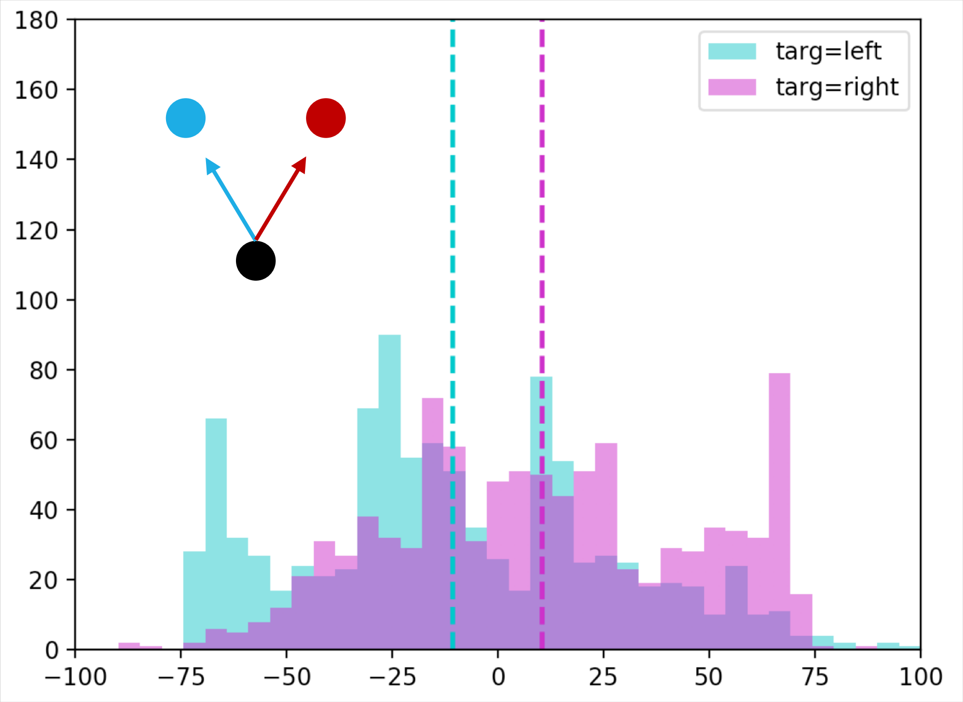
- Target appears
- Movement starts
- Contacts target

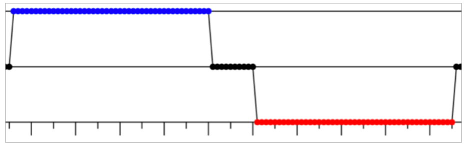


Distribution of error correlates with *targ*

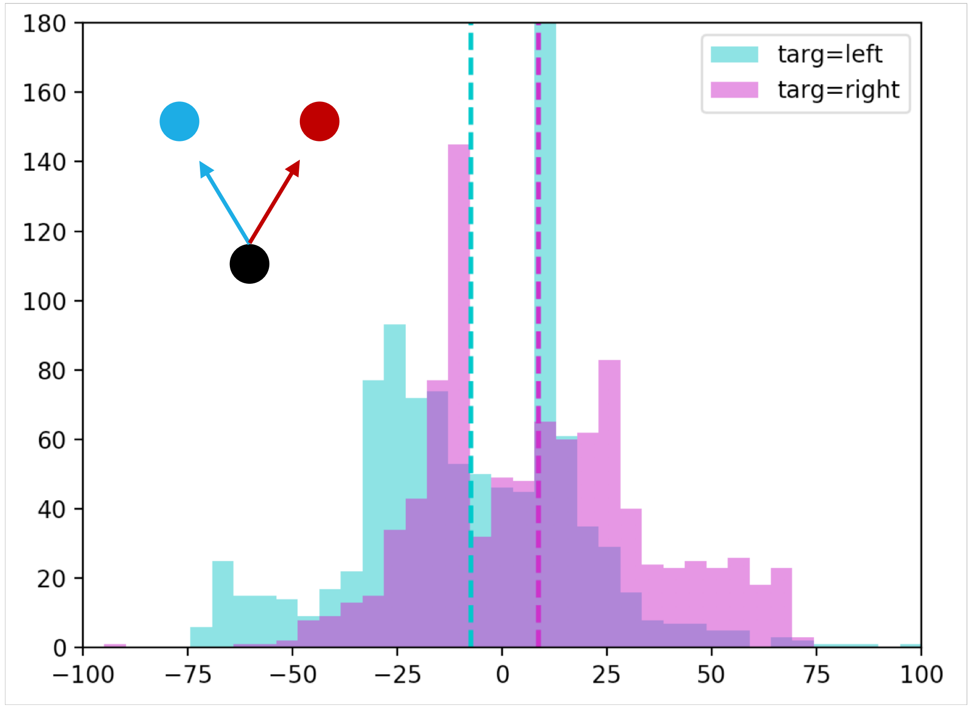


random condition

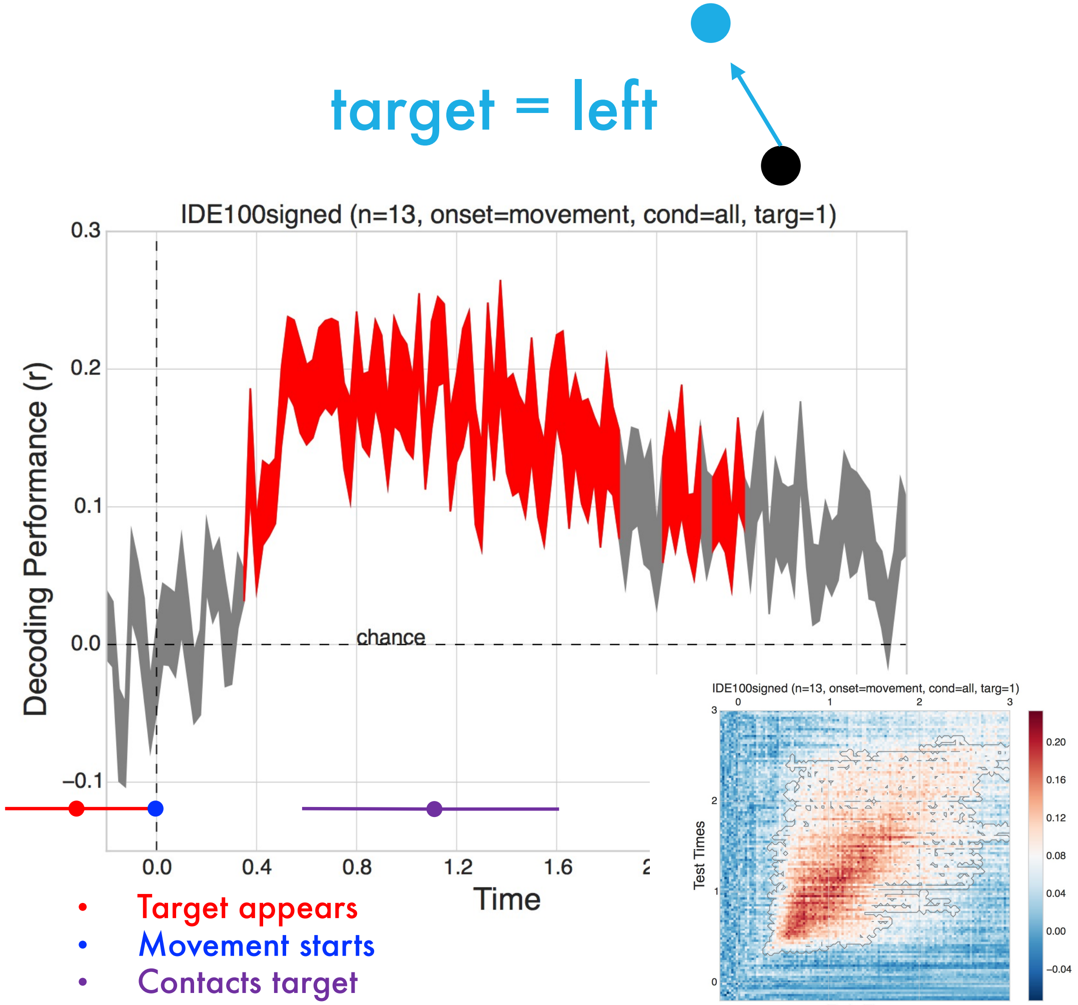


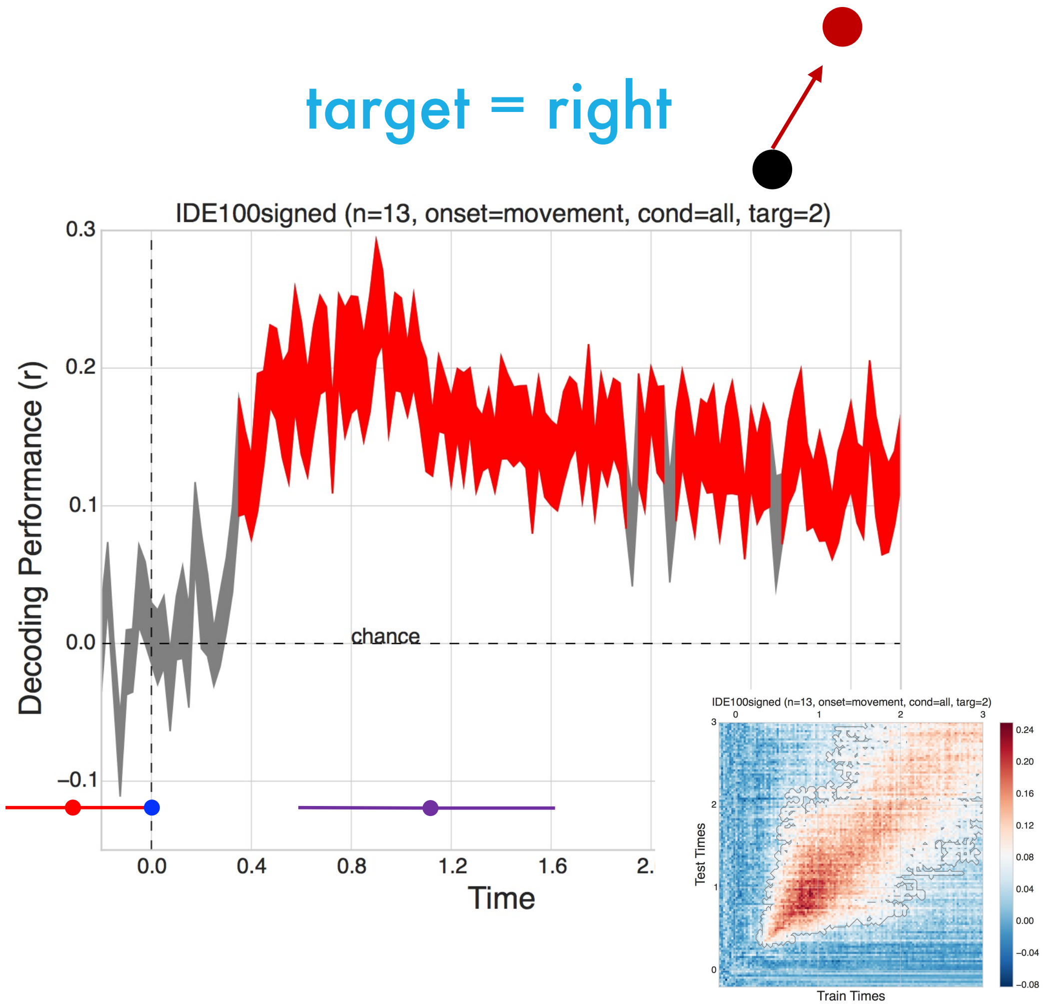


constant condition

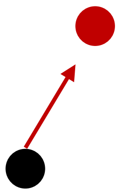


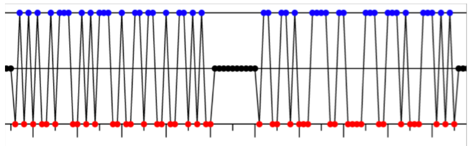
Split by Target Position



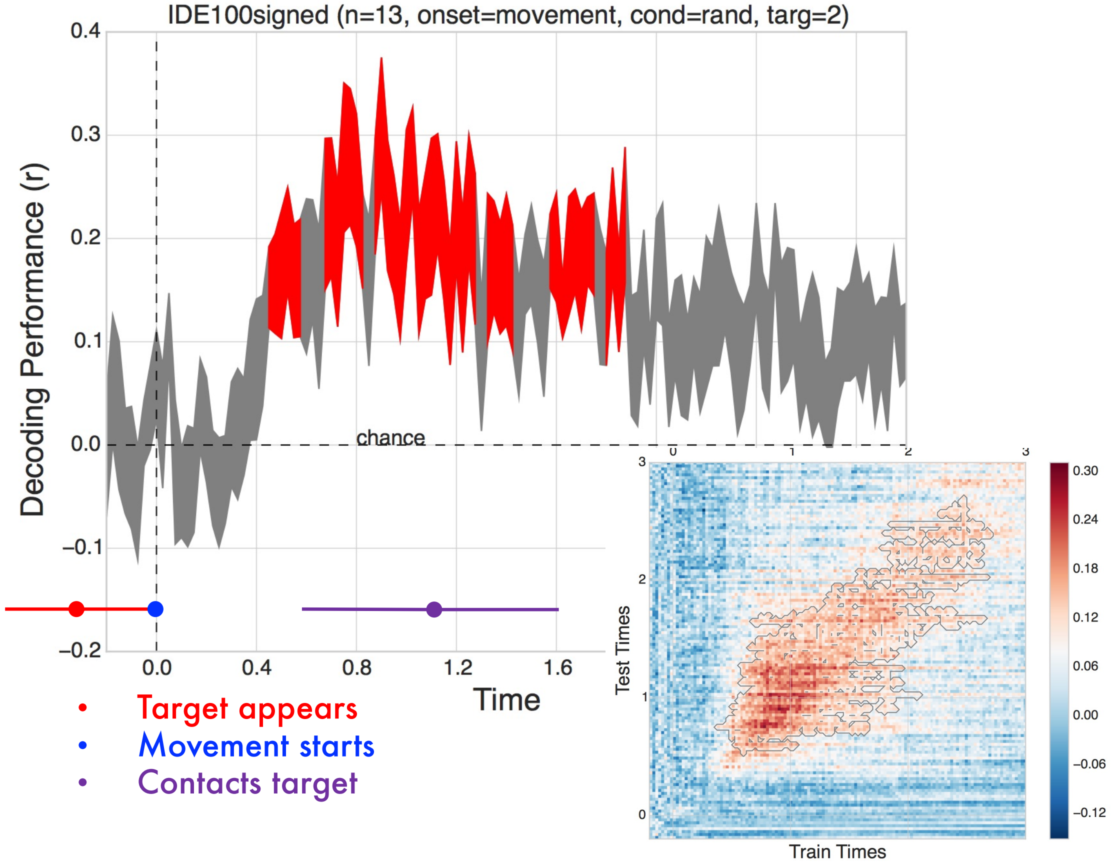


Split by Condition

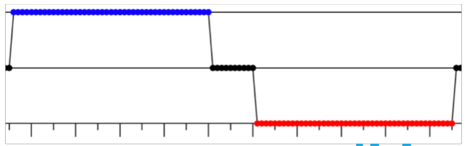




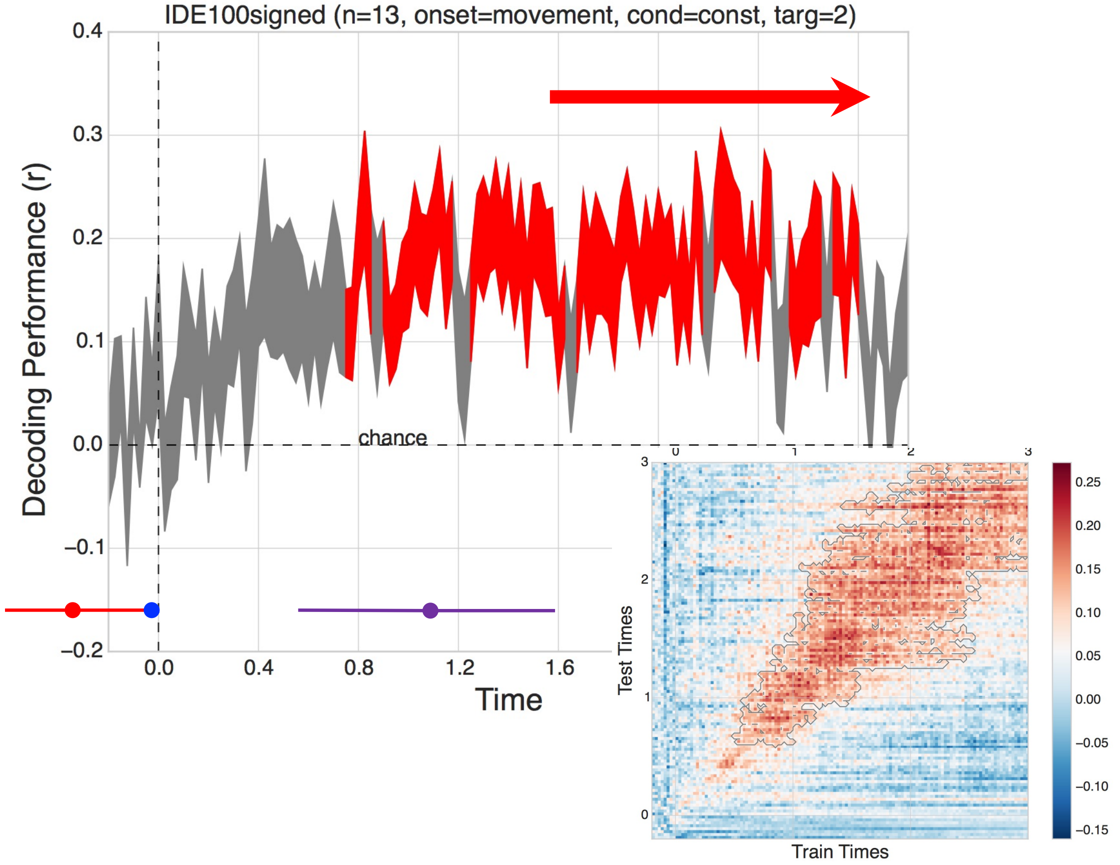
random condition



- Target appears
- Movement starts
- Contacts target

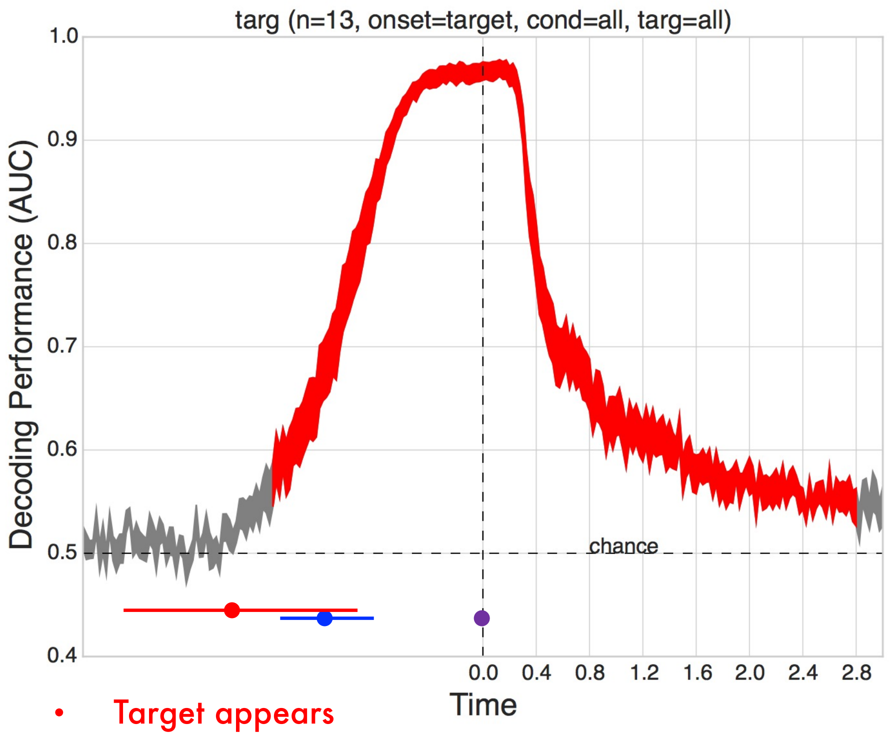


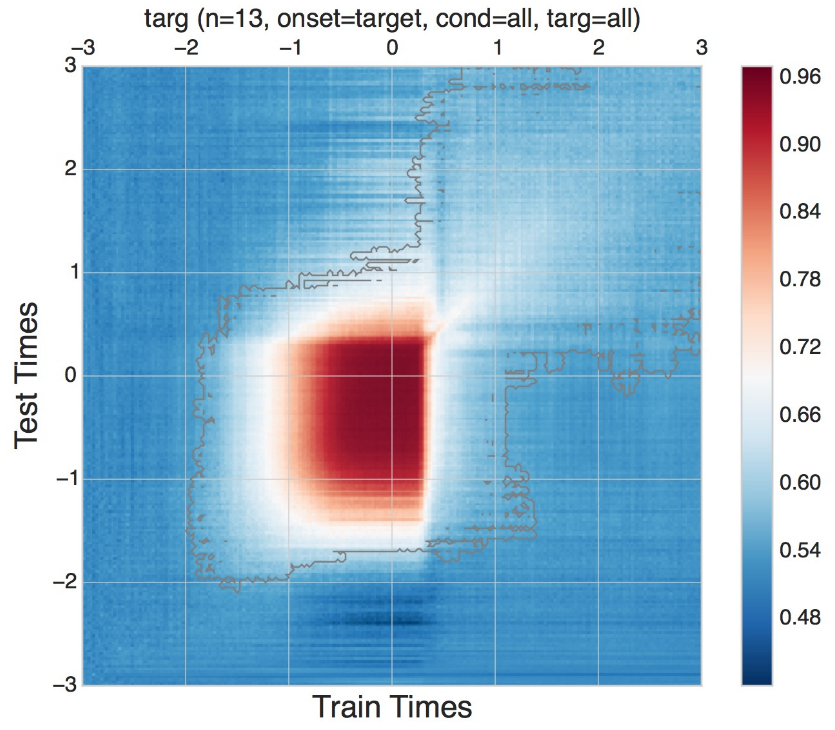
constant condition



Time-locking the Target Contact (targ)

Highest point = target contact, second activation = coming back!

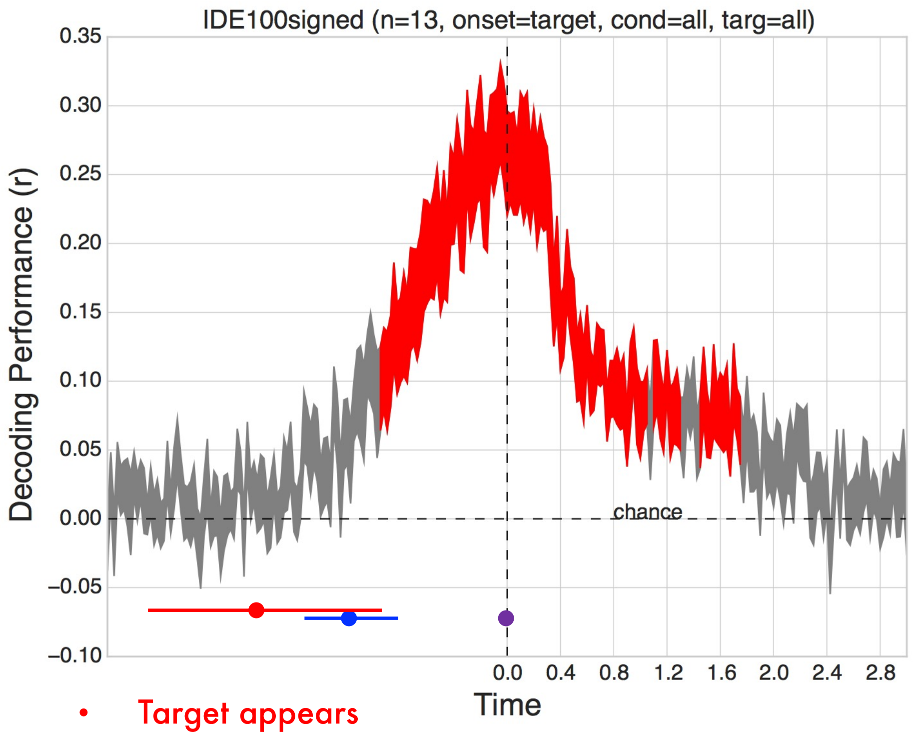




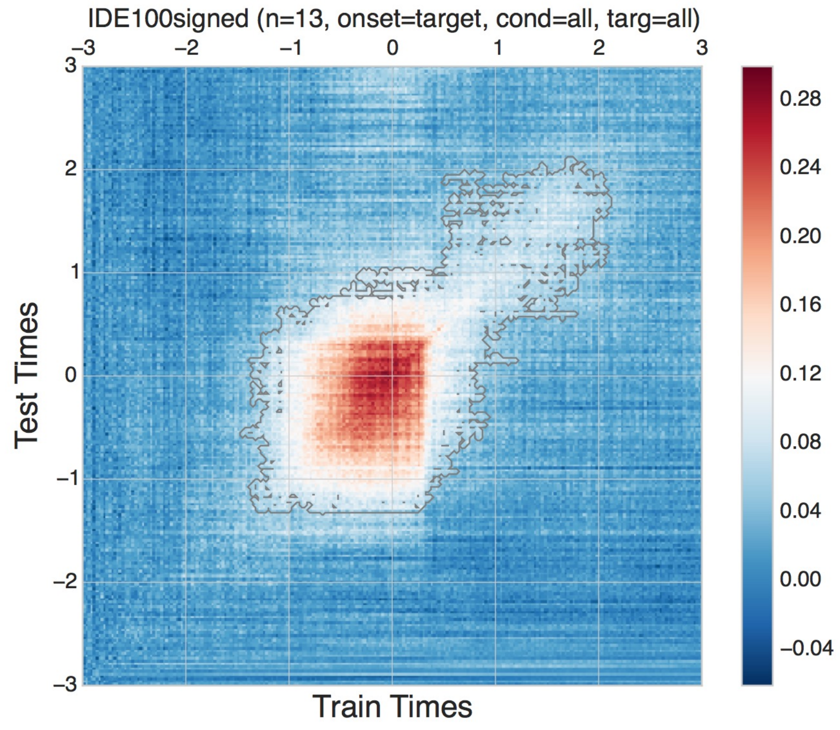
- Target appears
- Movement starts
- Contacts target

Time-locking the Target Contact (IDE 100ms)

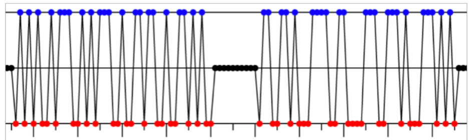
propagation from target position



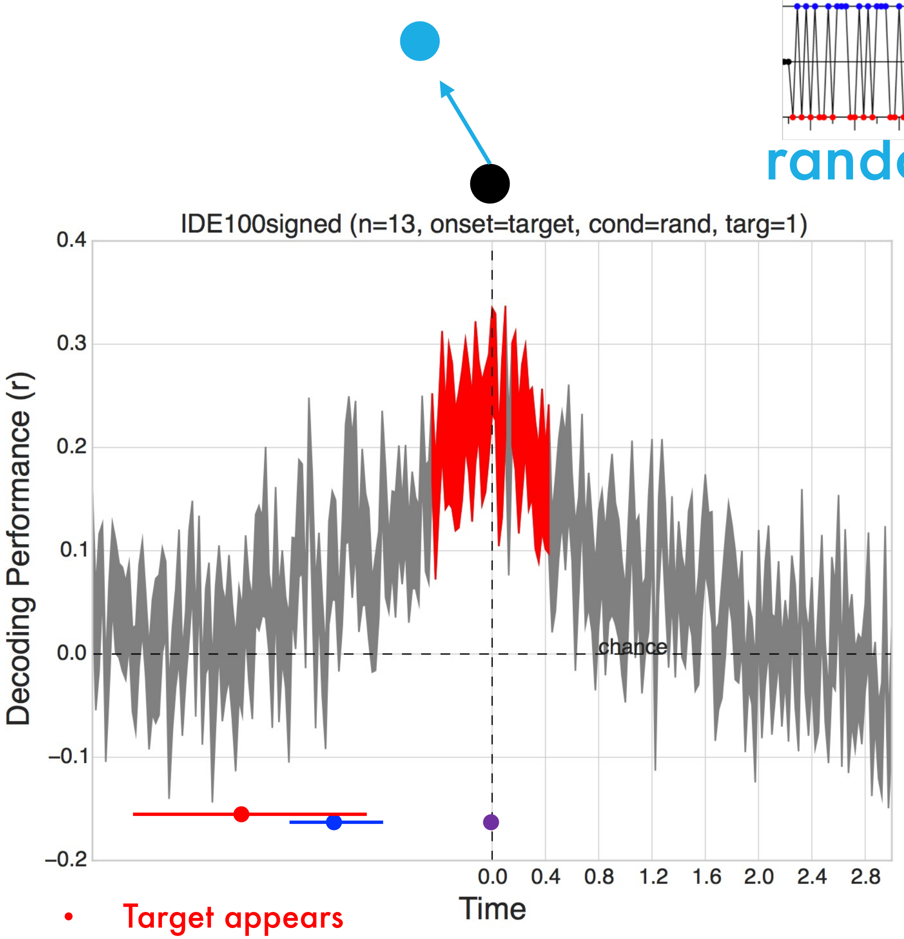
- Target appears
- Movement starts
- Contacts target

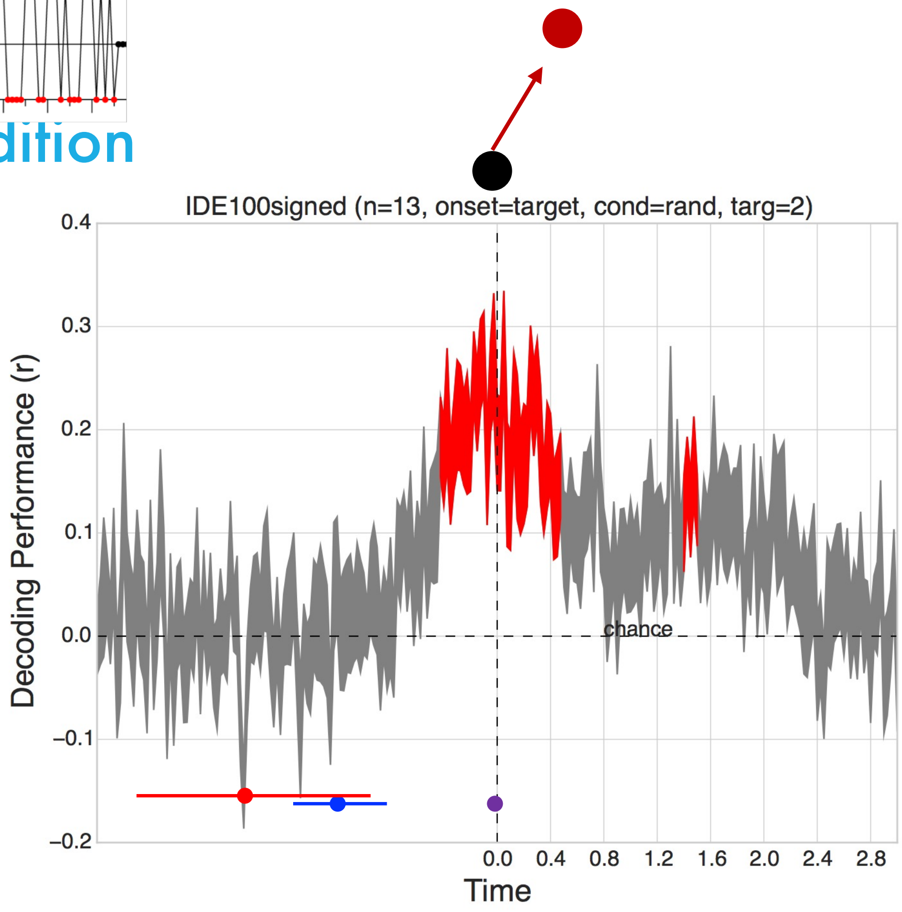


Time-locking the Target Contact (IDE 100ms)



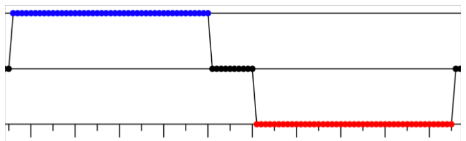
random condition



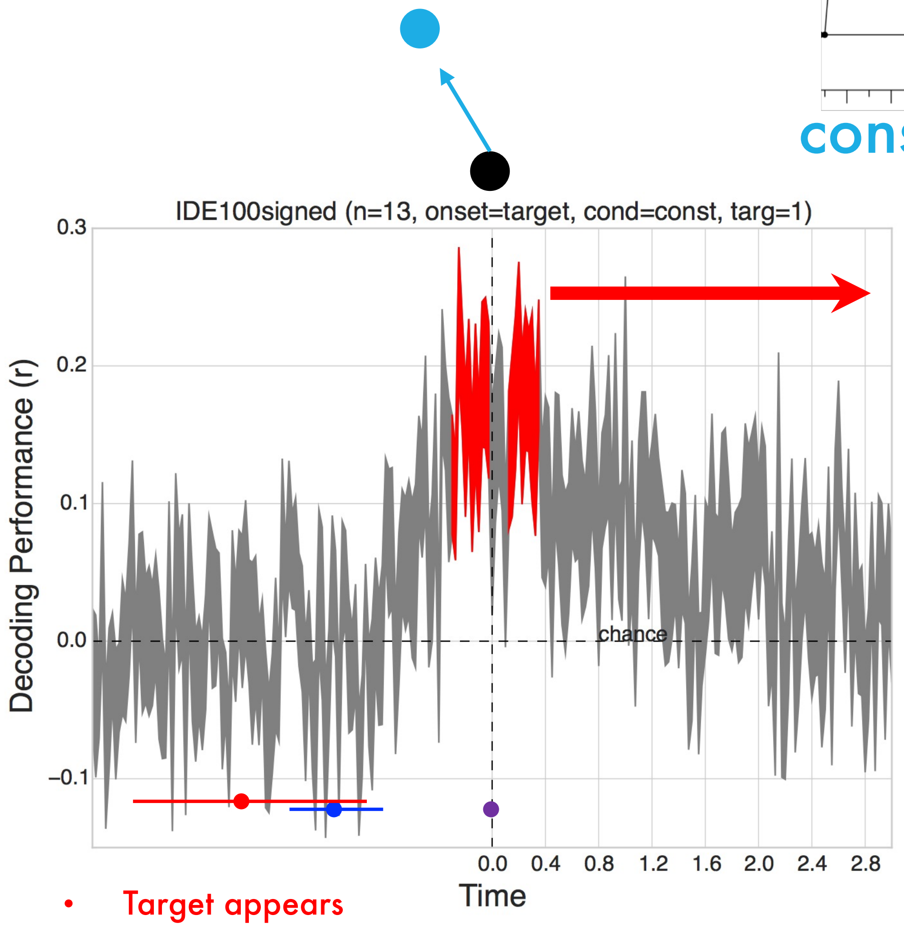


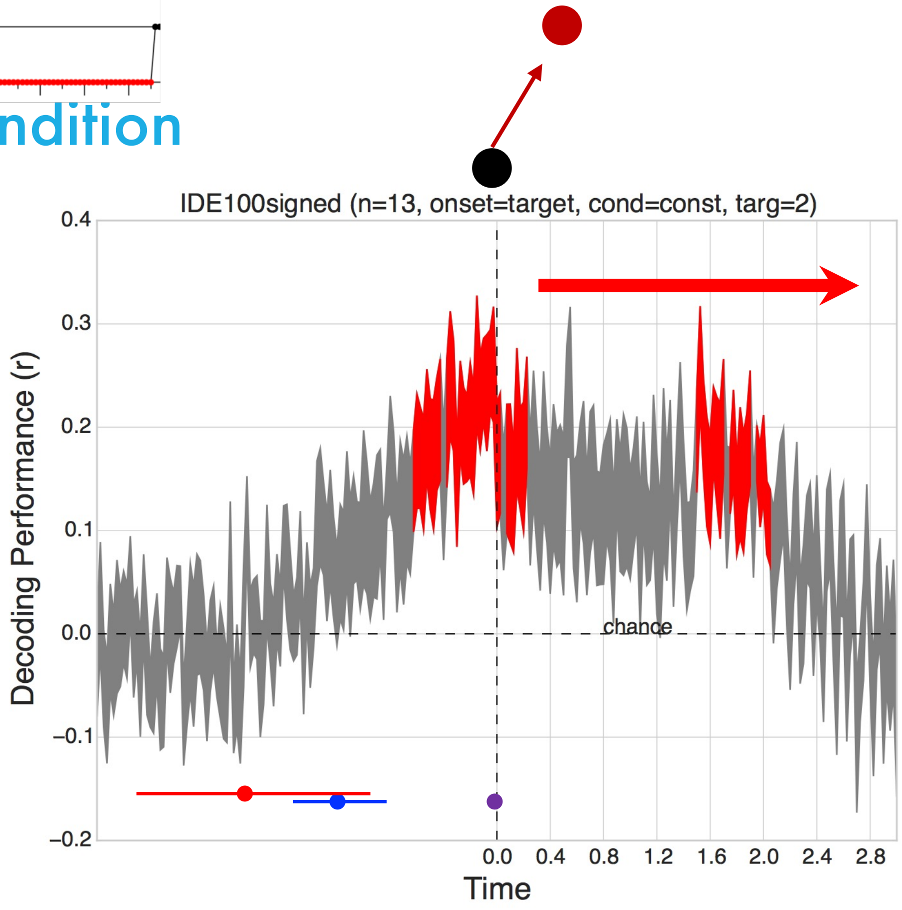
- Target appears
- Movement starts
- Contacts target

Time-locking the Target Contact (IDE 100ms)



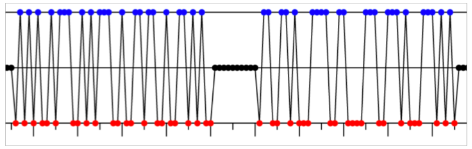
constant condition

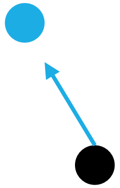


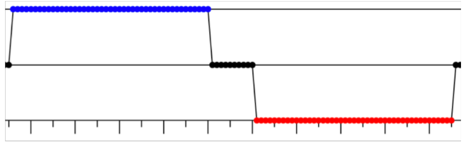


- Target appears
- Movement starts
- Contacts target

Time-locking the Target Contact (IDE 100ms)



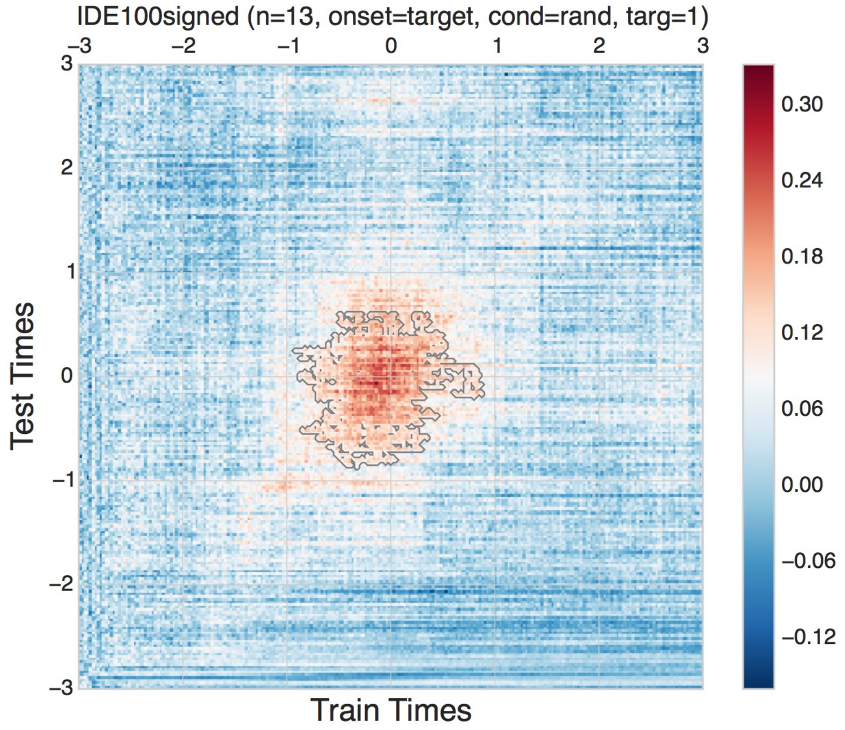


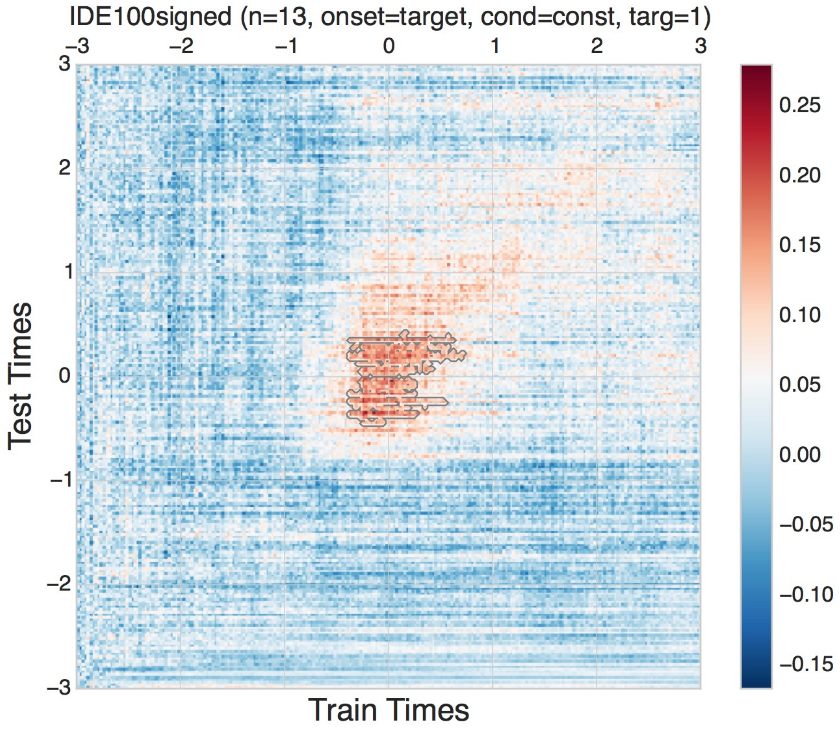


random condition

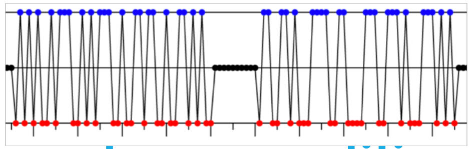
target = left

Constant condition



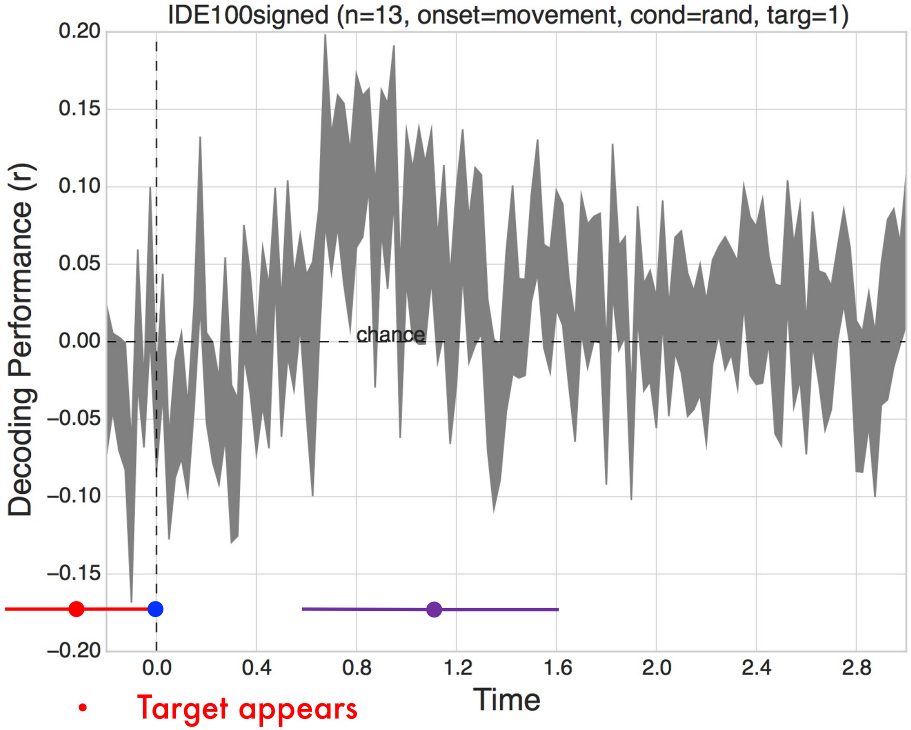


Cross-validation between Target Position

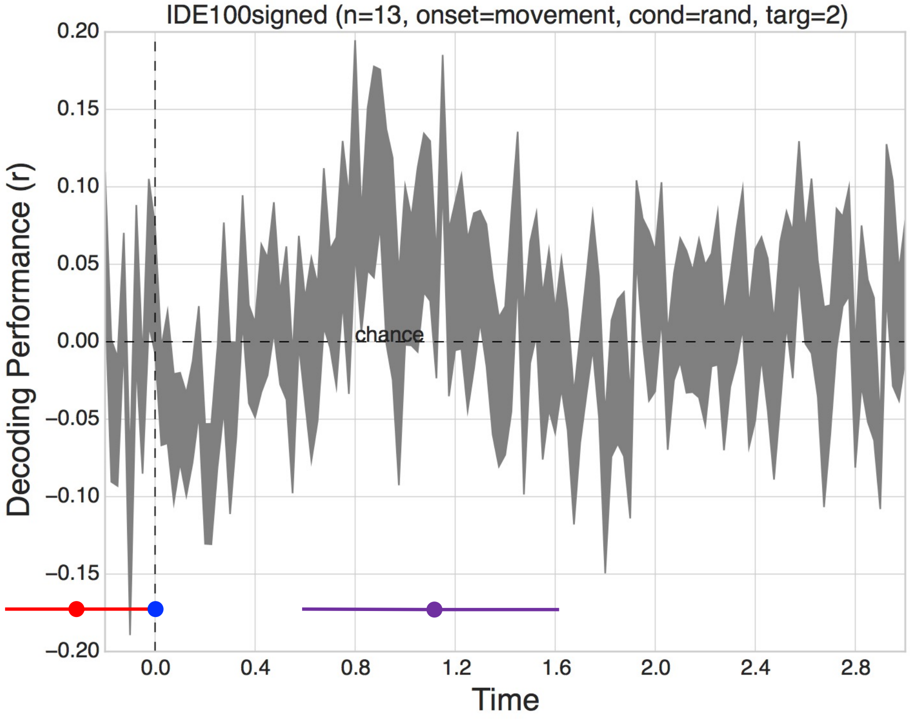


random condition

Train left, Test right



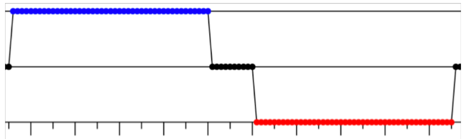
Train right, Test left



- Target appears
- Movement starts
- Contacts target

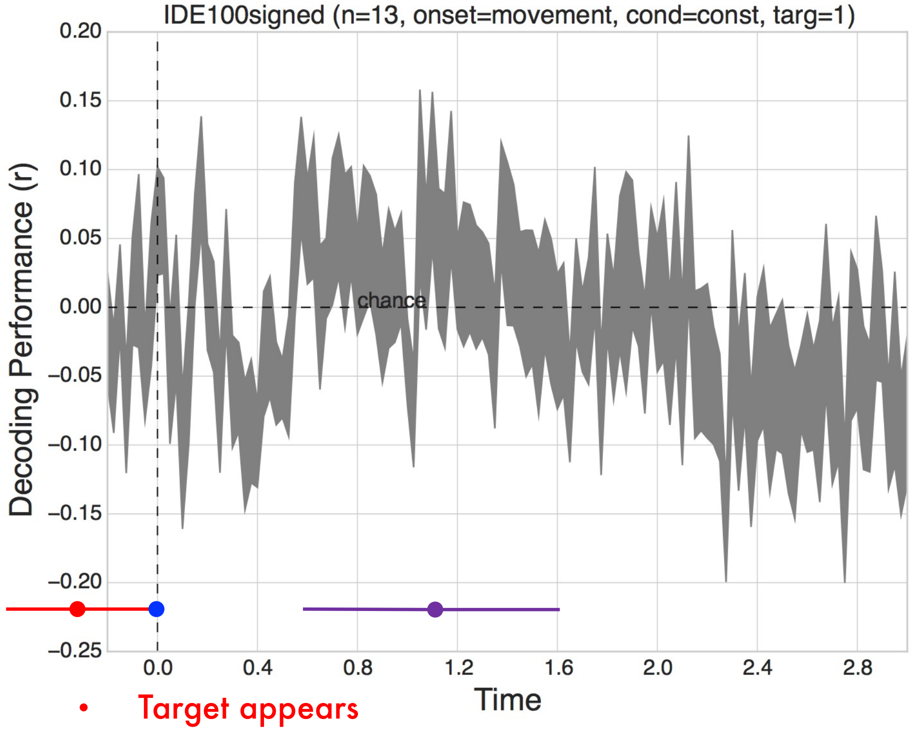
Cross-validation between Target Position

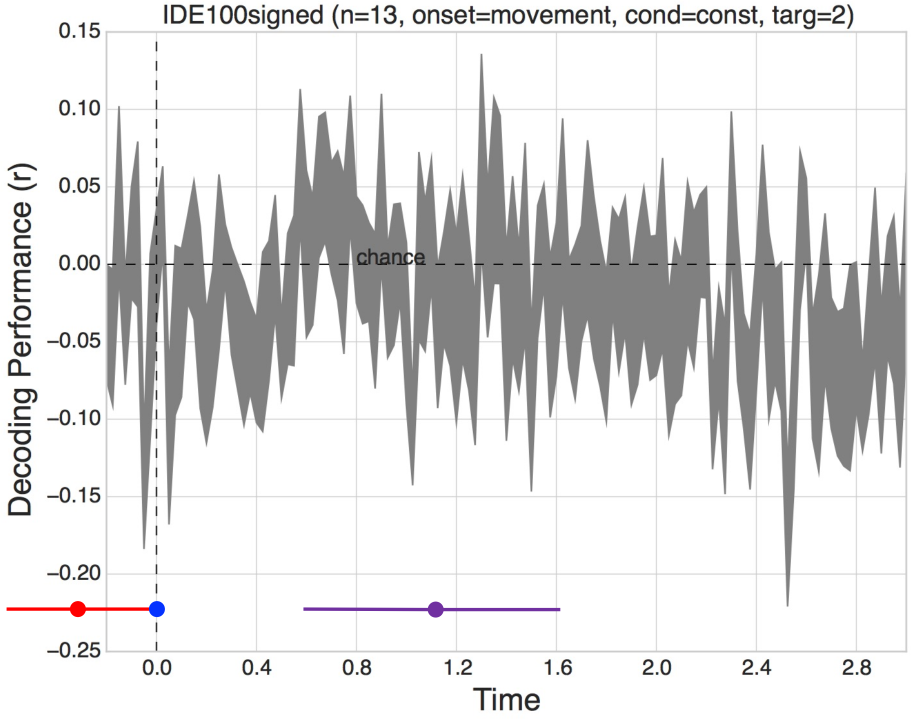
Train left, Test right



constant condition

Train right, Test left





- Target appears
- Movement starts
- Contacts target

Conclusion

1. We can decode the error of each trial

2. Decoding performance is
   - at its highest around the target contact
   - maintains longer when the condition is constant

Pilot Study: goal

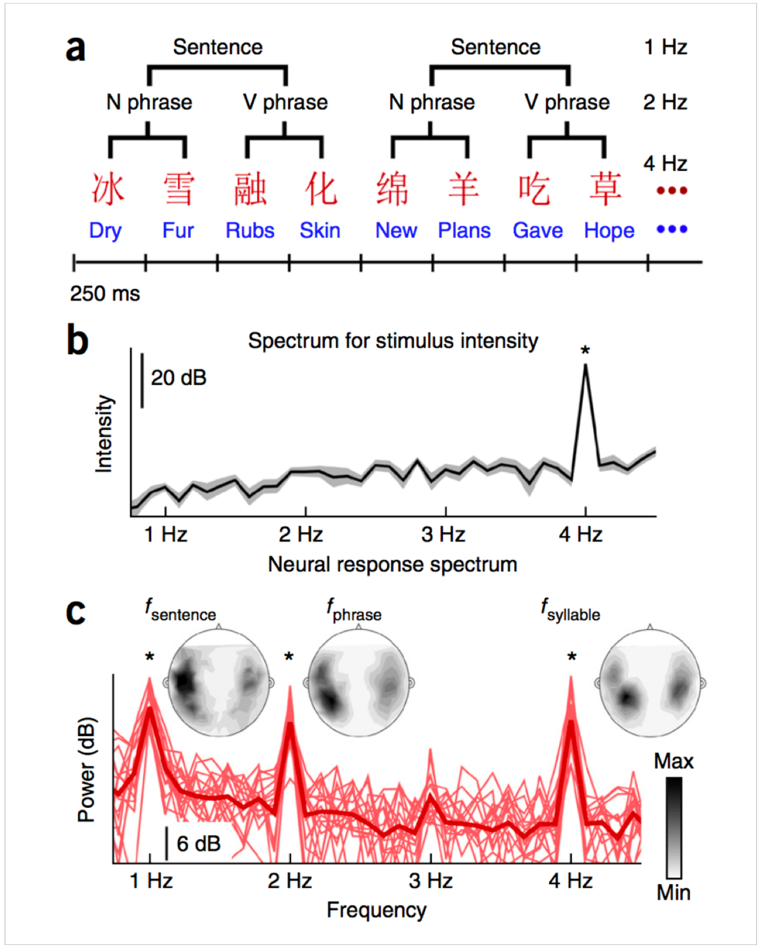
nature neuroscience

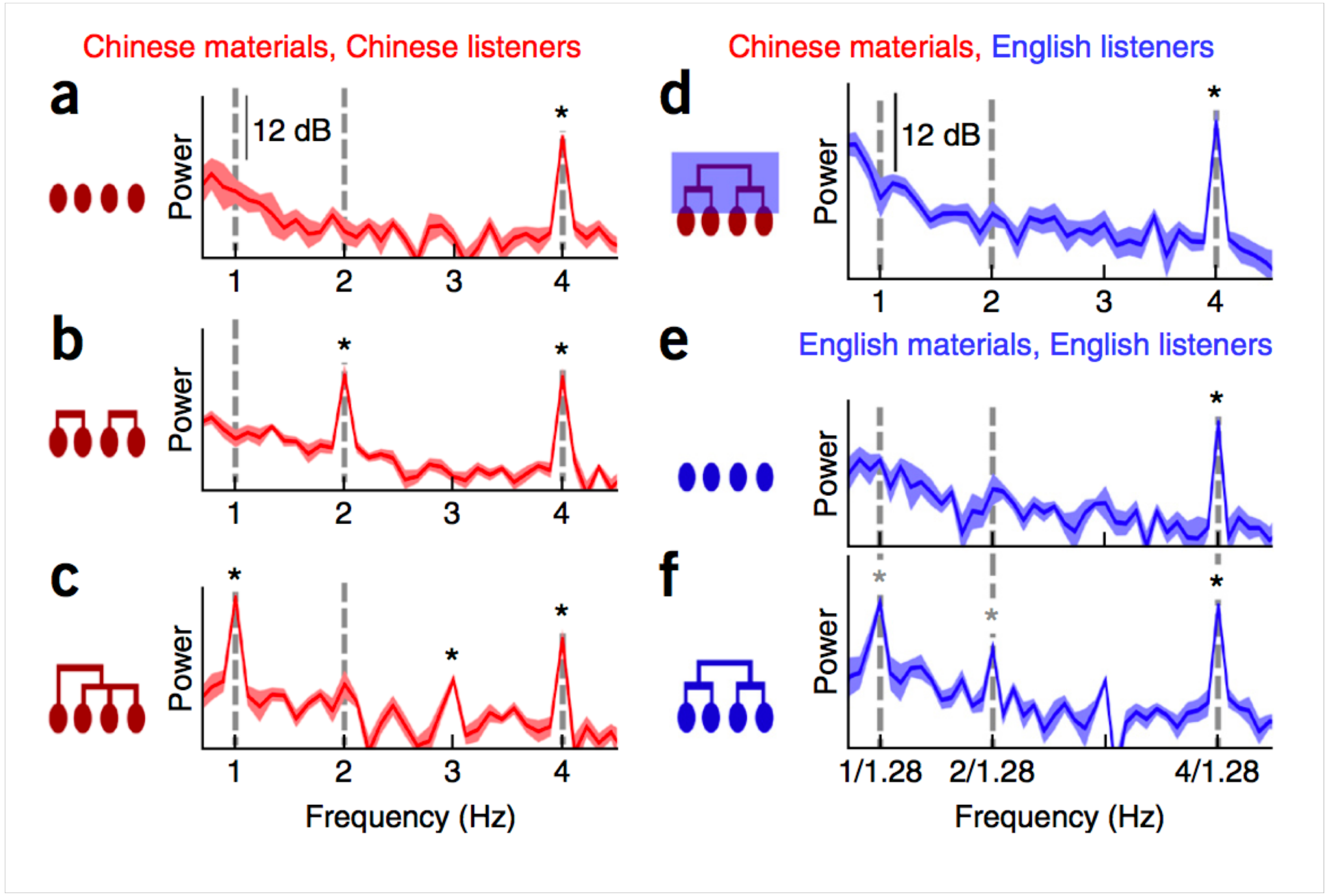
Cortical tracking of hierarchical linguistic structures in connected speech

Nai Ding[1,2], Lucia Melloni[3–5], Hang Zhang[1,6–8], Xing Tian[1,9,10] & David Poeppel[1,11]

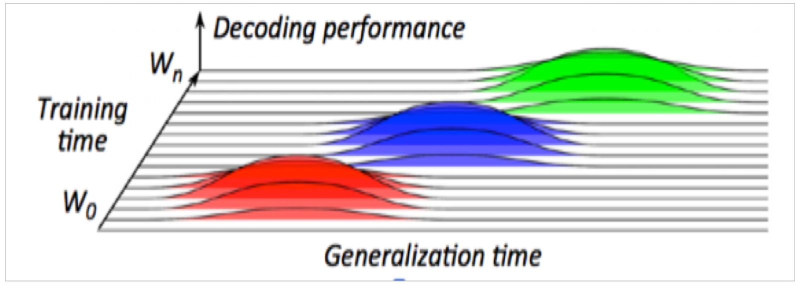
The most critical attribute of human language is its unbounded combinatorial nature: smaller elements can be combined into larger structures on the basis of a grammatical system, resulting in a hierarchy of linguistic units, such as words, phrases and sentences. Mentally parsing and representing such structures, however, poses challenges for speech comprehension. In speech, hierarchical linguistic structures do not have boundaries that are clearly defined by acoustic cues and must therefore be internally and incrementally constructed during comprehension. We found that, during listening to connected speech, cortical activity of different timescales concurrently tracked the time course of abstract linguistic structures at different hierarchical levels, such as words, phrases and sentences. Notably, the neural tracking of hierarchical linguistic structures was dissociated from the encoding of acoustic cues and from the predictability of incoming words. Our results indicate that a hierarchy of neural processing timescales underlies grammar-based internal construction of hierarchical linguistic structure.

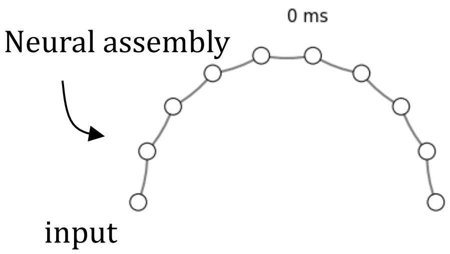
Pilot Study: goal

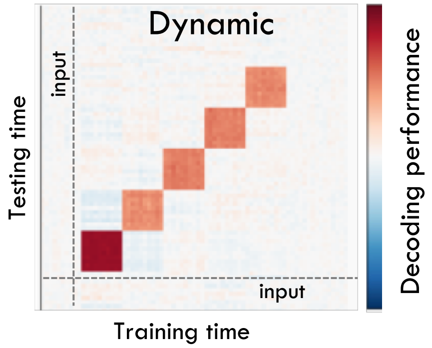


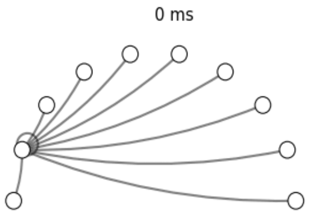


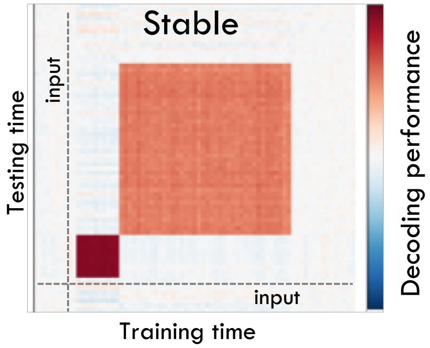
Using MVPA + GAT











King and Dehaene. 2014

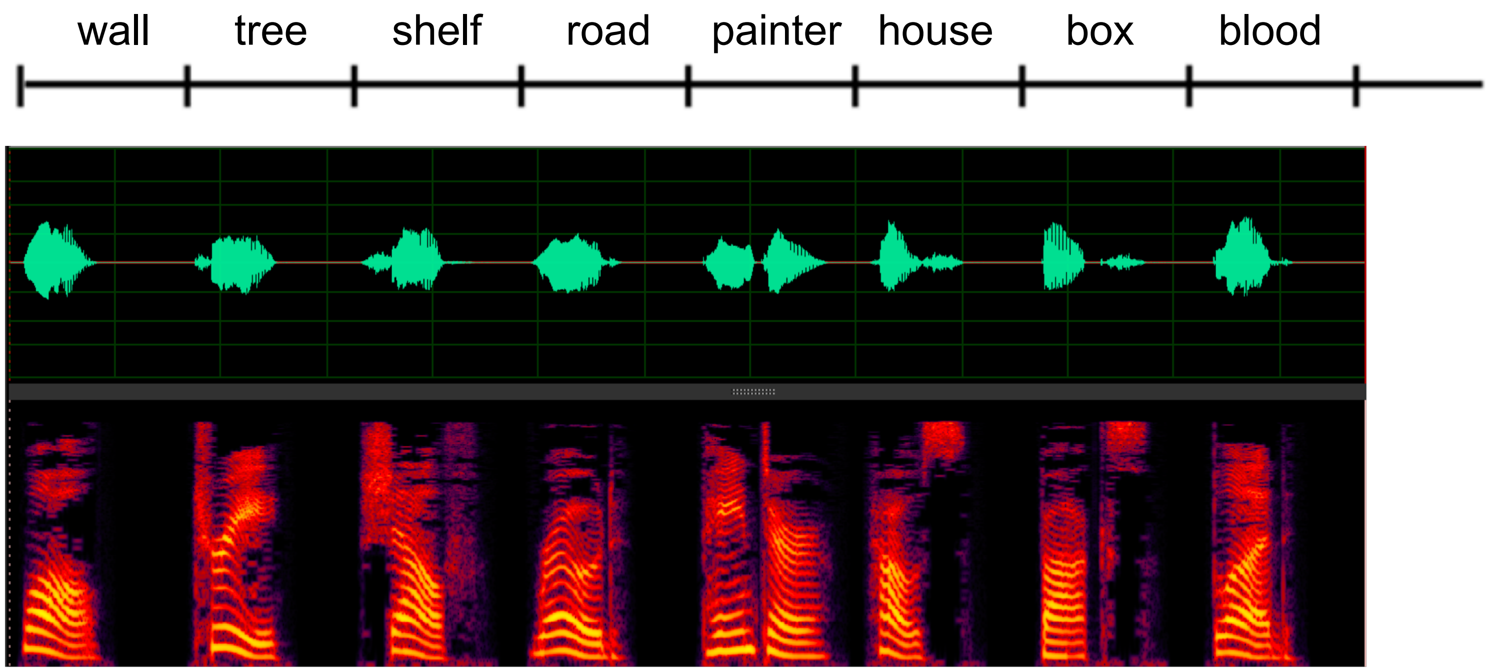
Experimental design

800 ms per word, 8 words per 'sentence'

1600 ms of beep in between, total 8 seconds per sentence

200 sentences per session

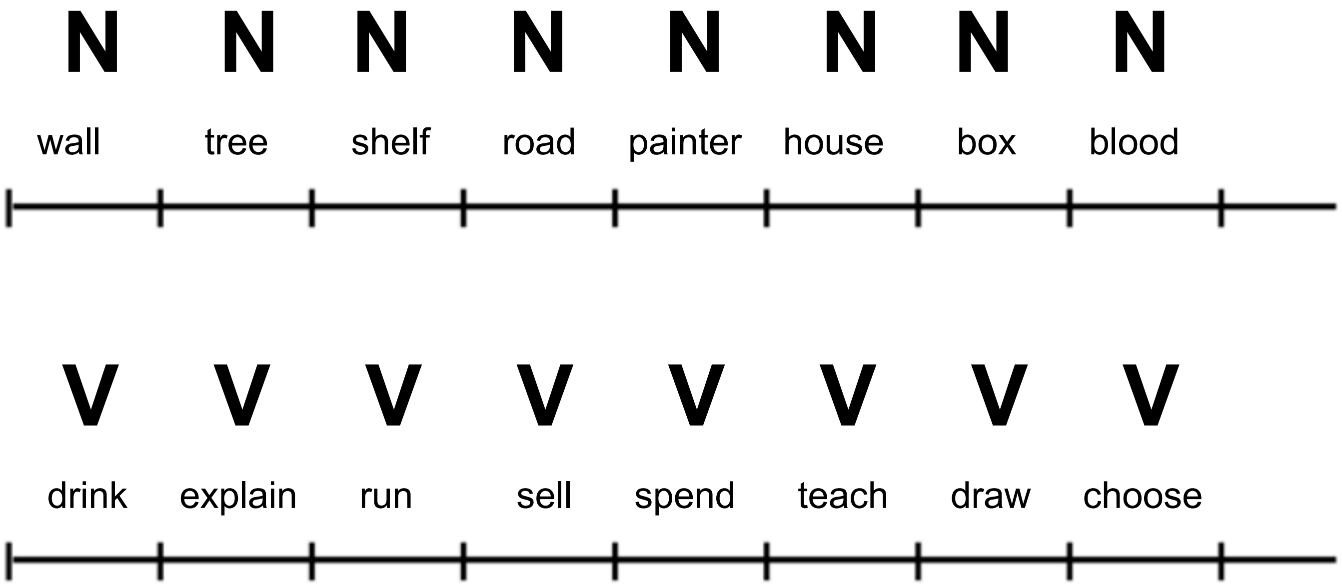
? sessions per language



Experimental design

1-word × 8

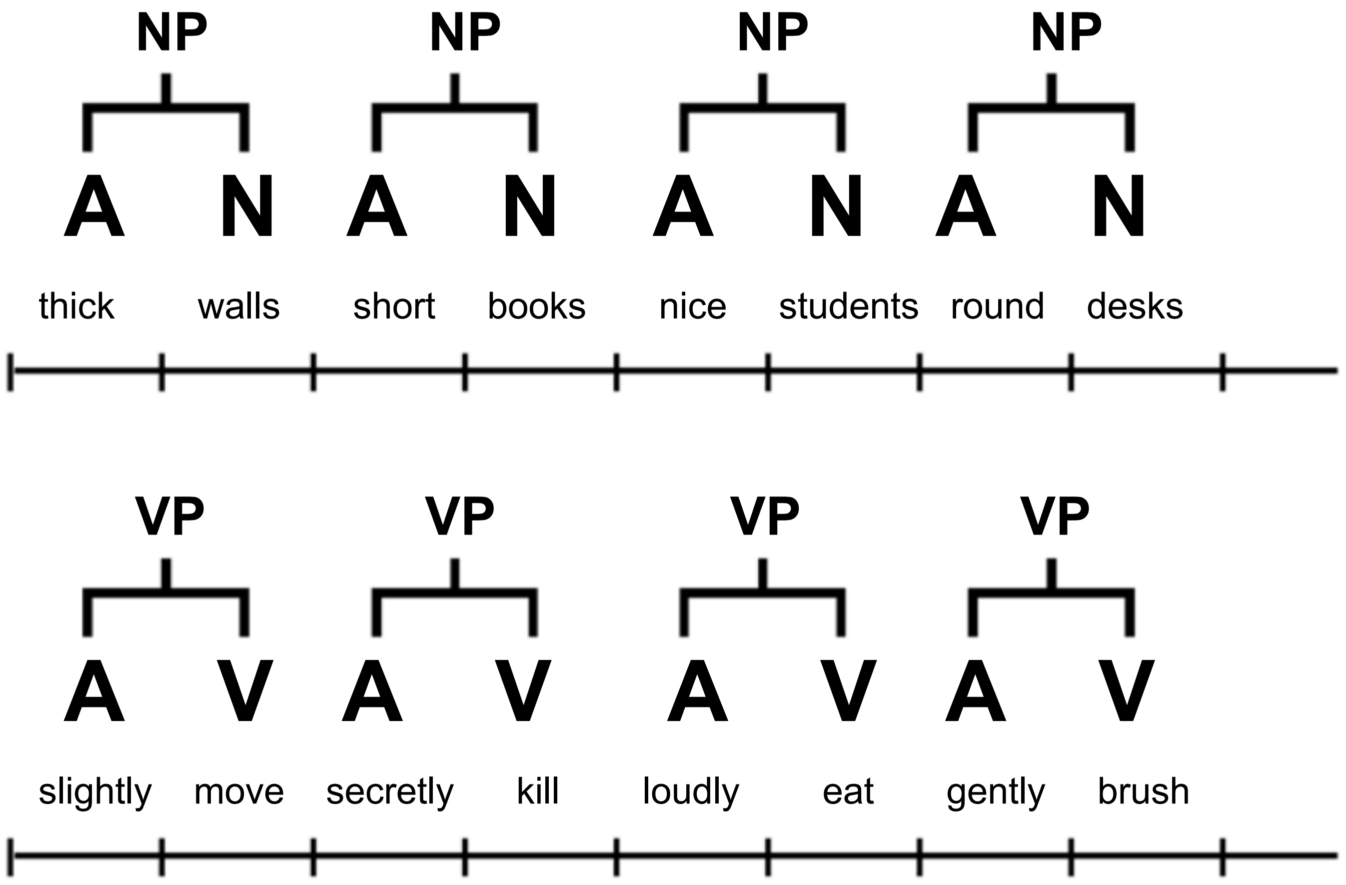
- Nouns
- Verbs



Experimental design

2-word × 4

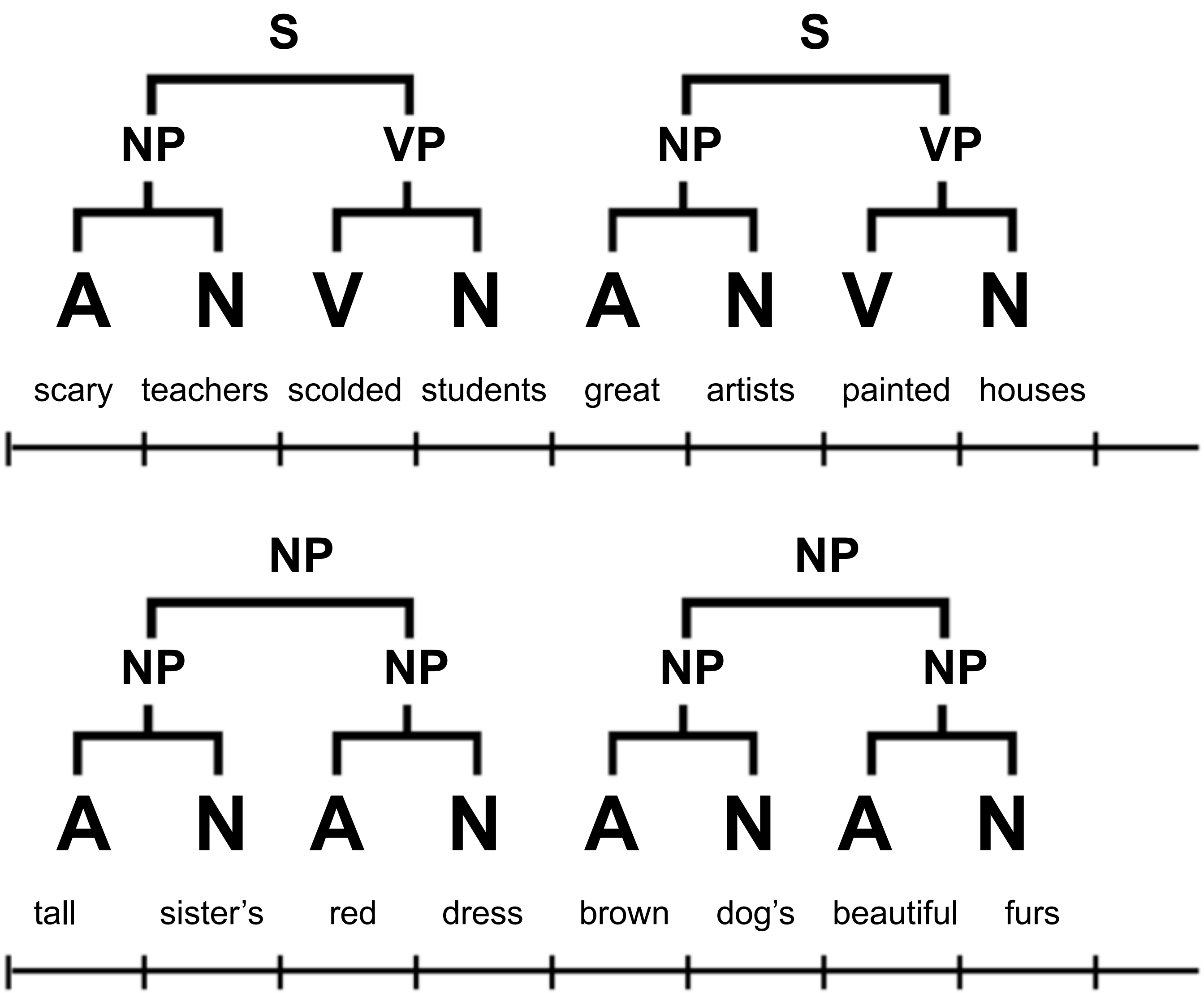
- Adjective + Noun
- Adverb + Verb



Experimental desig

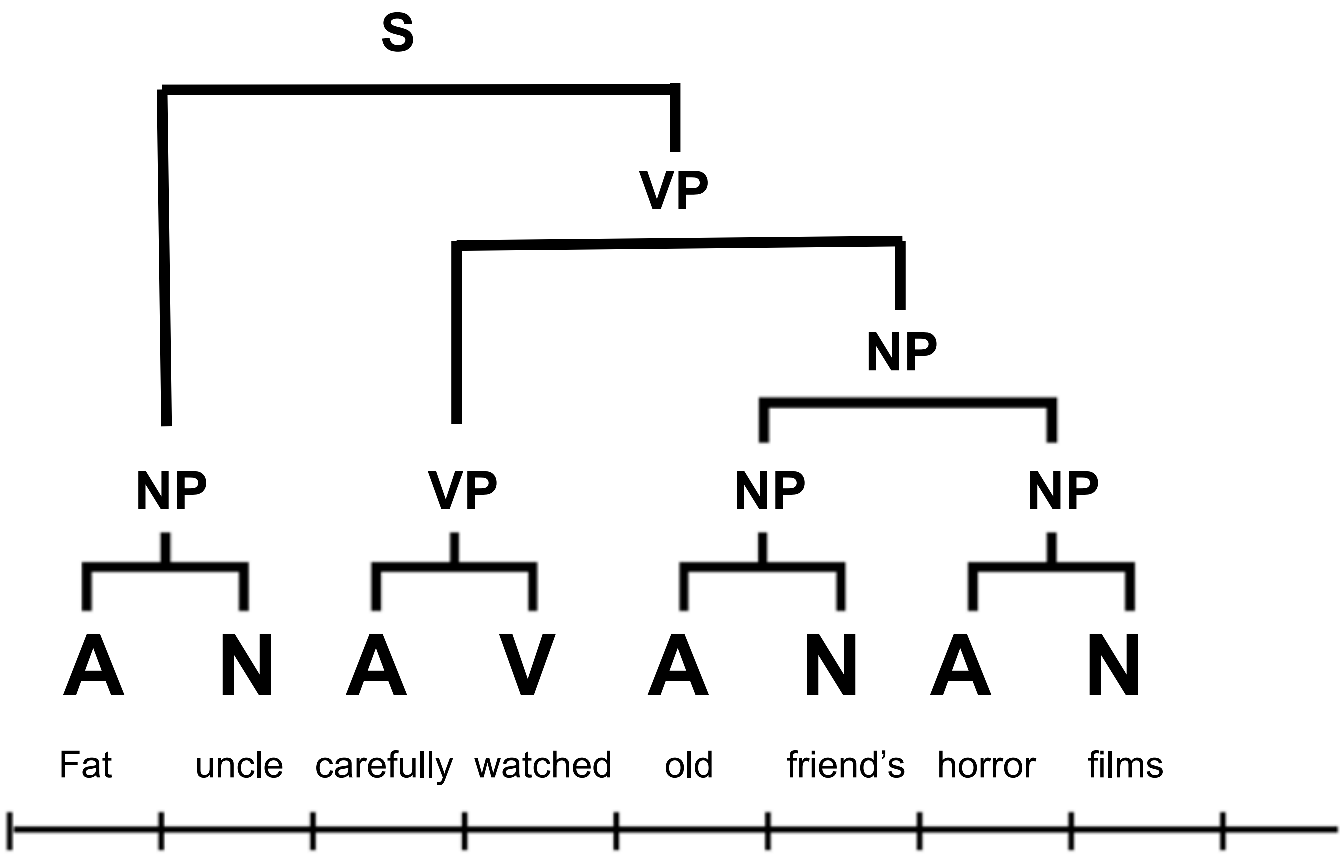
4-word × 2

- S [NP + VP]
- NP [NP + NP]



Experimental design

8-word × 1



Experimental design

1. Subject: French, Japanese native speaker
2. Language material: English, French, Japanese

Gros oncle a soigneusement regardé les films d'horreur de l'ancien ami

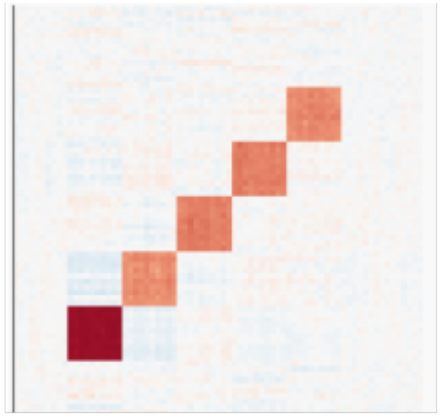
太った　叔父が　注意深く　古い　友人　ホラー　映画を　見た

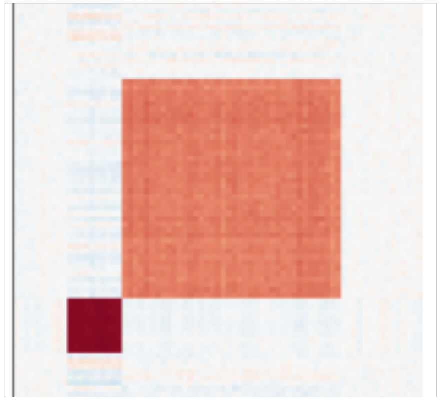
Fat　uncle　carefully　watched　old　friend’s　horror　films

Experimental design

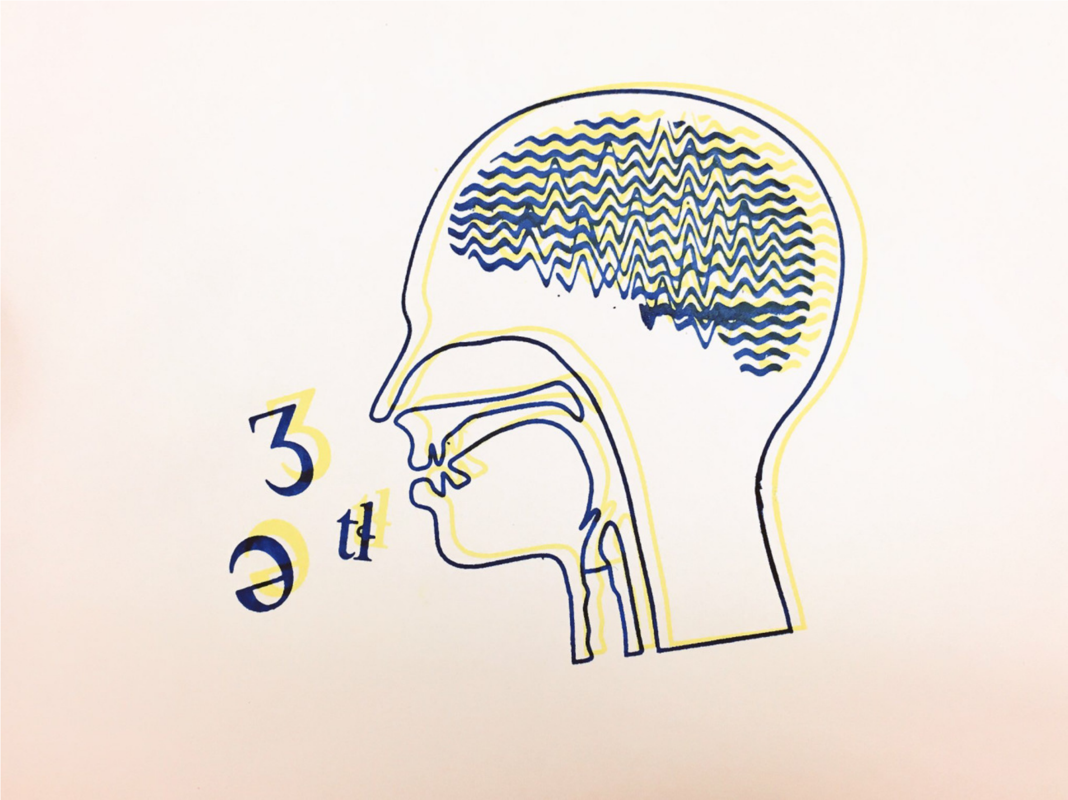
1. Subject: French, Japanese native speaker
2. Language material: English, French, Japanese

	Romain Quentin	English Speaker	Ippei Nojima
French	L1	-	-
Japanese	-	-	L1
English	L2	L1	L2





“When you talk”



*Gamsahamnida!

* *Thank you* in Korean