How to reveal neuro-computational mechanisms of reinforcement learning & decision-making?

It is easy to do with the hBayesDM package

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Reinforcement Learning and Decision-Making (RLDM)

Computational modeling

- Individual differences
- Latent processes (& their time course)

Review

Cell PRESS

Special Issue: Cognition in Neuropsychiatric Disorders

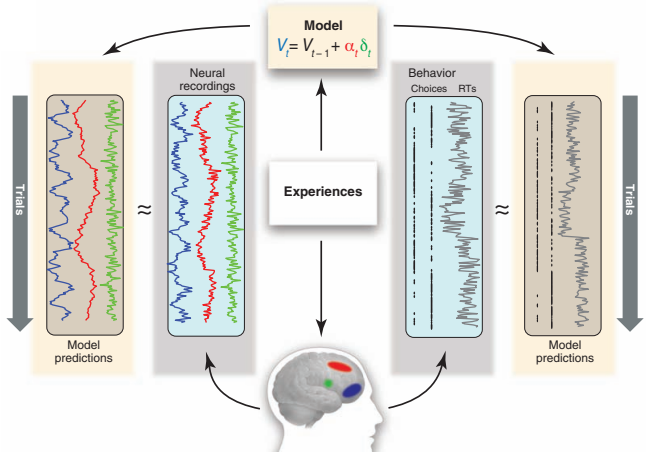
Computational psychiatry

P. Read Montague[1,2], Raymond J. Dolan[2], Karl J. Friston[2] and Peter Dayan[3]

Montague et al (2012) Trends in Cog Sci

Model-based fMRI/EEG

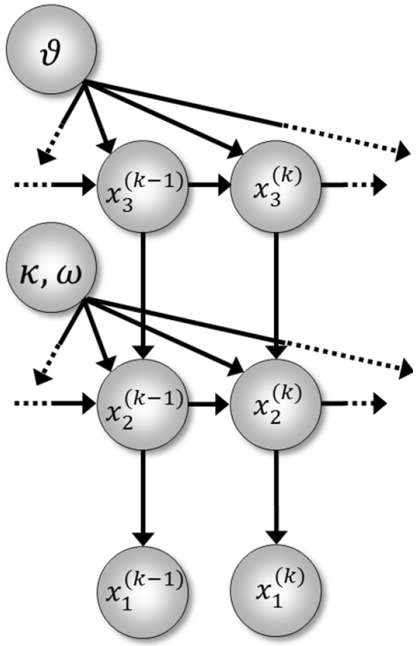
e.g., Forstmann & Wagenmakers (2015); O'Doherty et al (2007)



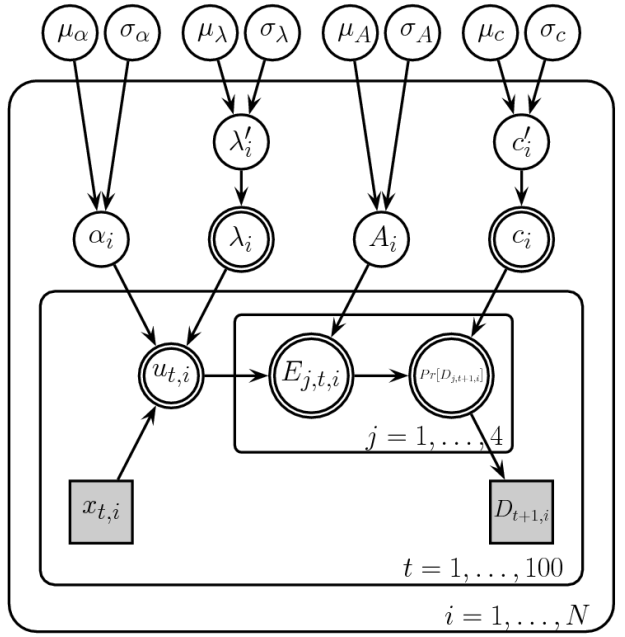
Behrens, Hunt, Rushworth (2009) Science

I like the idea of modeling

But…



Mathys et al (2011) Frontiers

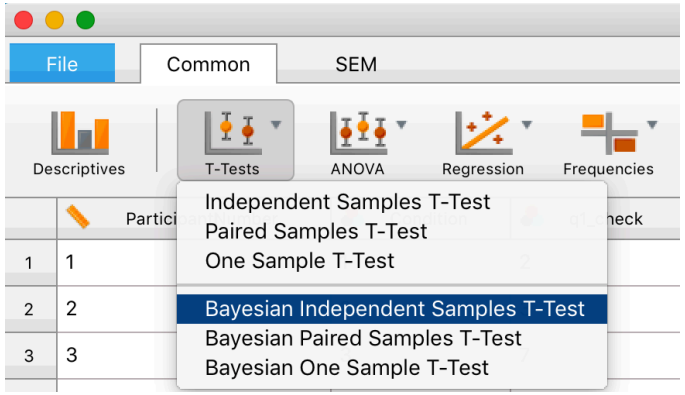


Ahn et al (2011) JNPE

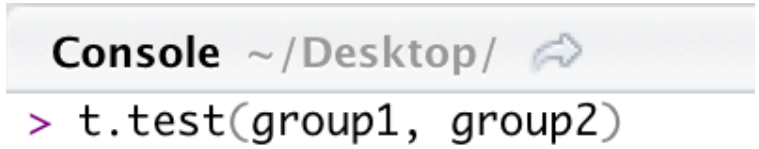
Can we make it easy to do computational modeling?

Q) As easy as doing a T-test?

JASP, SPSS



R

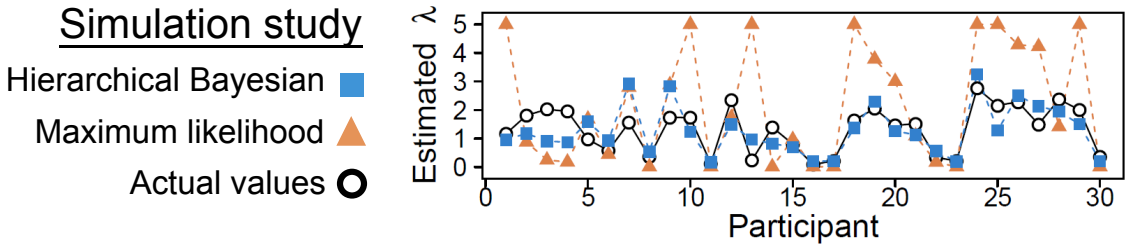


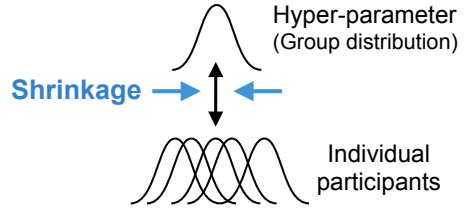
Several packages exist, but …

Matze et al (2013) Frontiers; Wabersich & Vandekerckhove (2014); Wiecki et al (2013) Frontiers; Daunizeau et al (2014) PLoS Comp Biol

hBayesDM *(hierarchical Bayesian modeling of Decision-Making tasks) Package*

- *Models for 8 tasks/paradigms (next slide)*
- *Single-line of coding in R*
  - *Model fitting, visualization, model comparisons*
- *Based on the advanced Bayesian software, Stan (https://mc-stan.org).*
- *Hierarchical Bayesian modeling*





Ahn et al (2011) JNPE

What tasks and models are available? Ahn & Busemeyer (2016) Curr Opin Behav Sci

- Delay Discounting (e.g., Mazur, 1987)
- *Iowa Gambling* (Bechara et al, 1994)
- *(Orthogonalized) Go/Nogo (Guitart-Masip et al, 2012)*
- *Two-choice Bandit (Experience-based) including Reversal Learning* (e.g., Erev et al, 2010)
- *Two-choice Description-based*

(e.g., Sokol-Hessner et al, 2009; Tom et al, 2007)

- *Ultimatum Game* (e.g., Xiang et al, 2013)
- **Two-Step* (Daw et al, 2011)

**Version 0.4.0. or later*

How can I use it?

Tutorials available at

http://rpubs.com/CCSL/hBayesDM

(you can find it by Googling ‘hBayesDM’)

Install it just like other R packages

```
install.packages("hBayesDM", dependencies=TRUE)
```

```
devtools::install_github("CCS-Lab/hBayesDM")
```

Brief step-by-step tutorials

1. *Prepare raw (trial-by-trial) data*
2. *Fit candidate models*
3. *Plot (visualize) and inspect model parameters*
4. *Compare models (if there exist competing models)*

The Orthogonalized Go/Nogo task

- `gng_m1`
- `gng_m2`
- `gng_m3`
- `gng_m4`

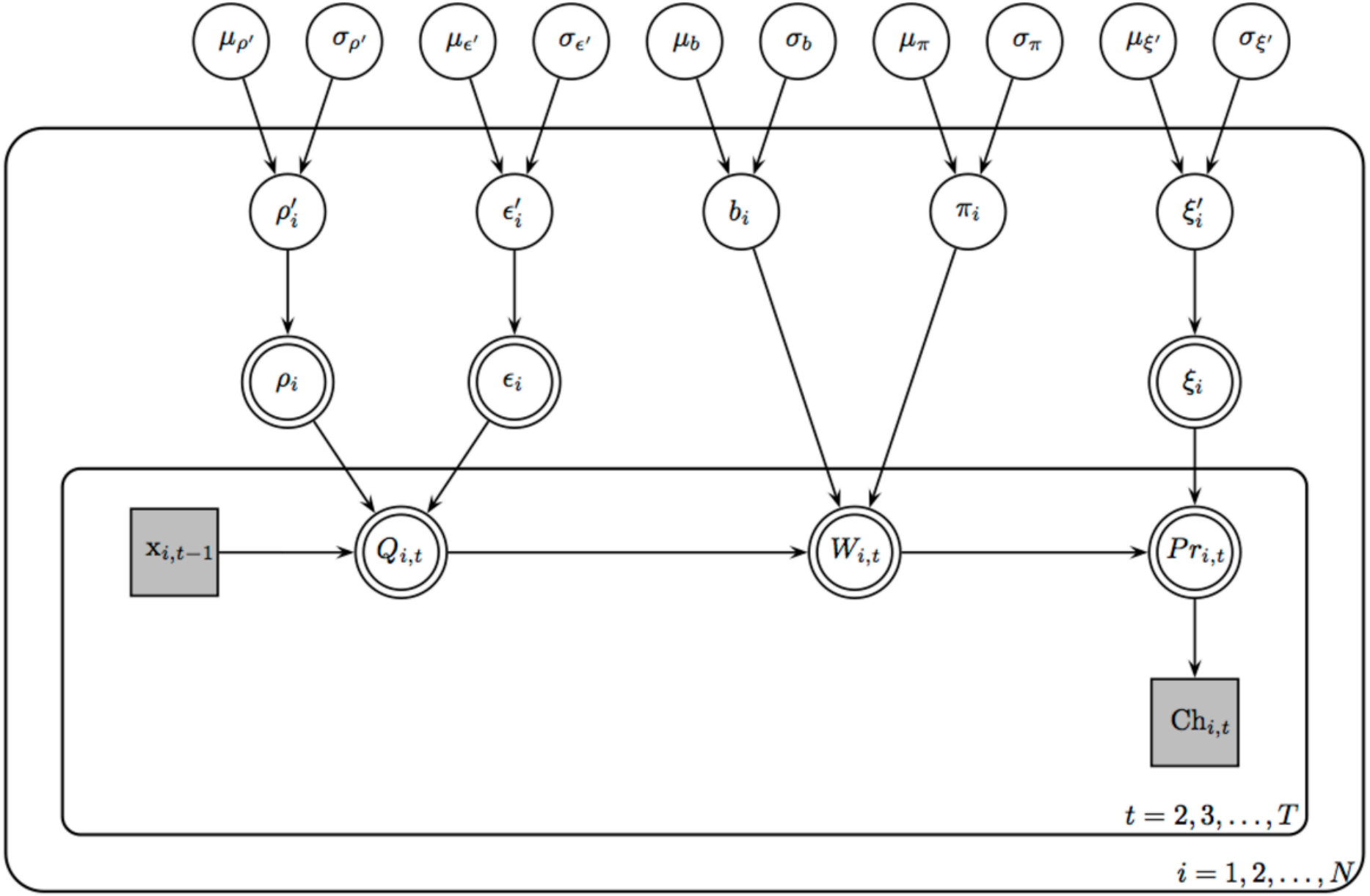
Guitart-Masip et al, 2012 Neuroimage

Cavanagh et al, 2013 J Neuro

1. *Prepare raw (trial-by-trial) data as a single text file*

	A	B	C	D	E	F	G
1	trialNum	cue	keyPressed	success	congruentOutcome	outcome	subjID
2	1	1	1	1	2	0	1
3	2	2	0	1	1	1	1
4	3	4	0	1	1	0	1
5	4	4	1	0	1	-1	1
6	5	4	0	1	1	0	1
7	6	1	1	1	1	1	1
8	7	3	0	0	1	-1	1
9	8	1	1	1	1	1	1
10	9	3	1	1	1	0	1
11	10	3	0	0	1	-1	1
12	11	4	0	1	1	0	1
13	12	4	0	1	1	0	1
14	13	4	0	1	1	0	1

2. Fit candidate models



2. Fit candidate models

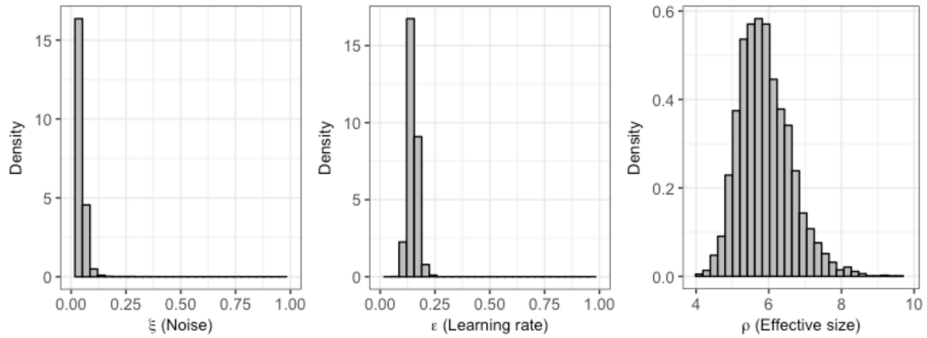
```
output1 = gng_m1(data="example", niter=2000, nwarmup=1000, nchain=4, ncore=4)
```

```
output1 = gng_m1("example", ncore=4)
```

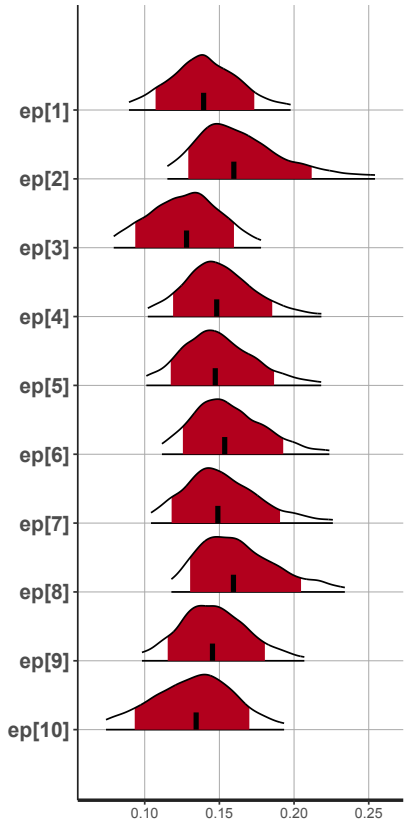
```
output1 = gng_m1()
```

3. Plot (visualize) and inspect model parameters

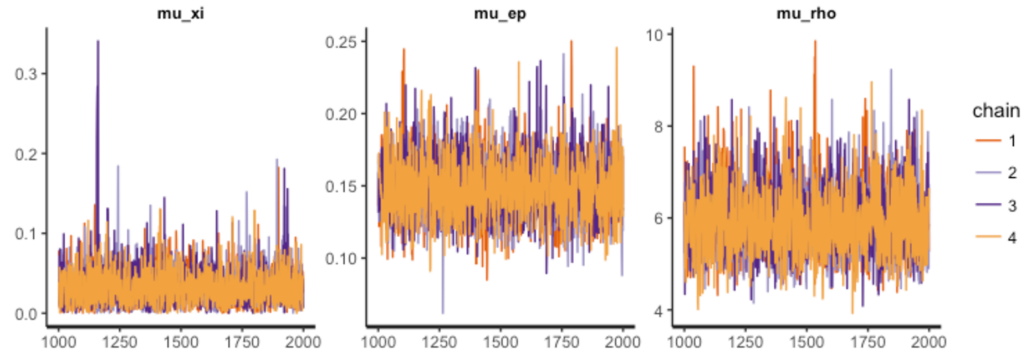
```
plot(output1)
```




```
plotInd(output1, "ep")
```




```
plot(output1, type="trace", fontSize=11)
```



4. Bayesian model comparisons

Vehtari et al. (2016)

Leave-One-Out Information Criterion (LOOIC) - default

Widely Applicable Information Criterion (WAIC)

```
> printFit(output1, output2, output3, output4)
   Model    LOOIC
1 gng_m1 1588.843
2 gng_m2 1571.129
3 gng_m3 1573.872
4 gng_m4 1543.335
```

Model #4 is the best model
(in terms of LOOIC)

More features!

- Bayesian group comparisons
- *Model-based regressors (e.g., trial-by-trial prediction errors) for model-based fMRI/EEG
- More tasks / models!

I don’t have much quantitative background, can I still do computational modeling?

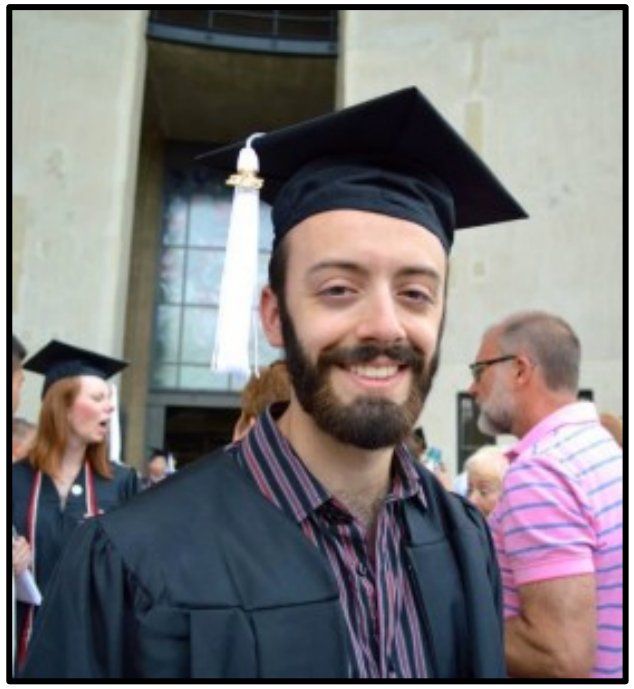
Yes! Please check our tutorials/poster @ http://rpubs.com/CCSL/hBayesDM

GitHub: https://github.com/CCS-Lab/hBayesDM

Can I add more models? Can you add more features? Can I contribute?

Yes! hBayesDM is also for experts. It is a work in progress. Please let us know if you have or need cool models!

Thank you!



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Ahn, W.-Y., Haines, N., & Zhang, L. (2016). Revealing neuro-computational mechanisms of reinforcement learning and decision-making with the hBayesDM package. bioRxiv. http://doi.org/10.1101/064287