

# Neural Network Reconstruction from SPES-Response Data

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## Single Pulse Electrical Stimulation (SPES)

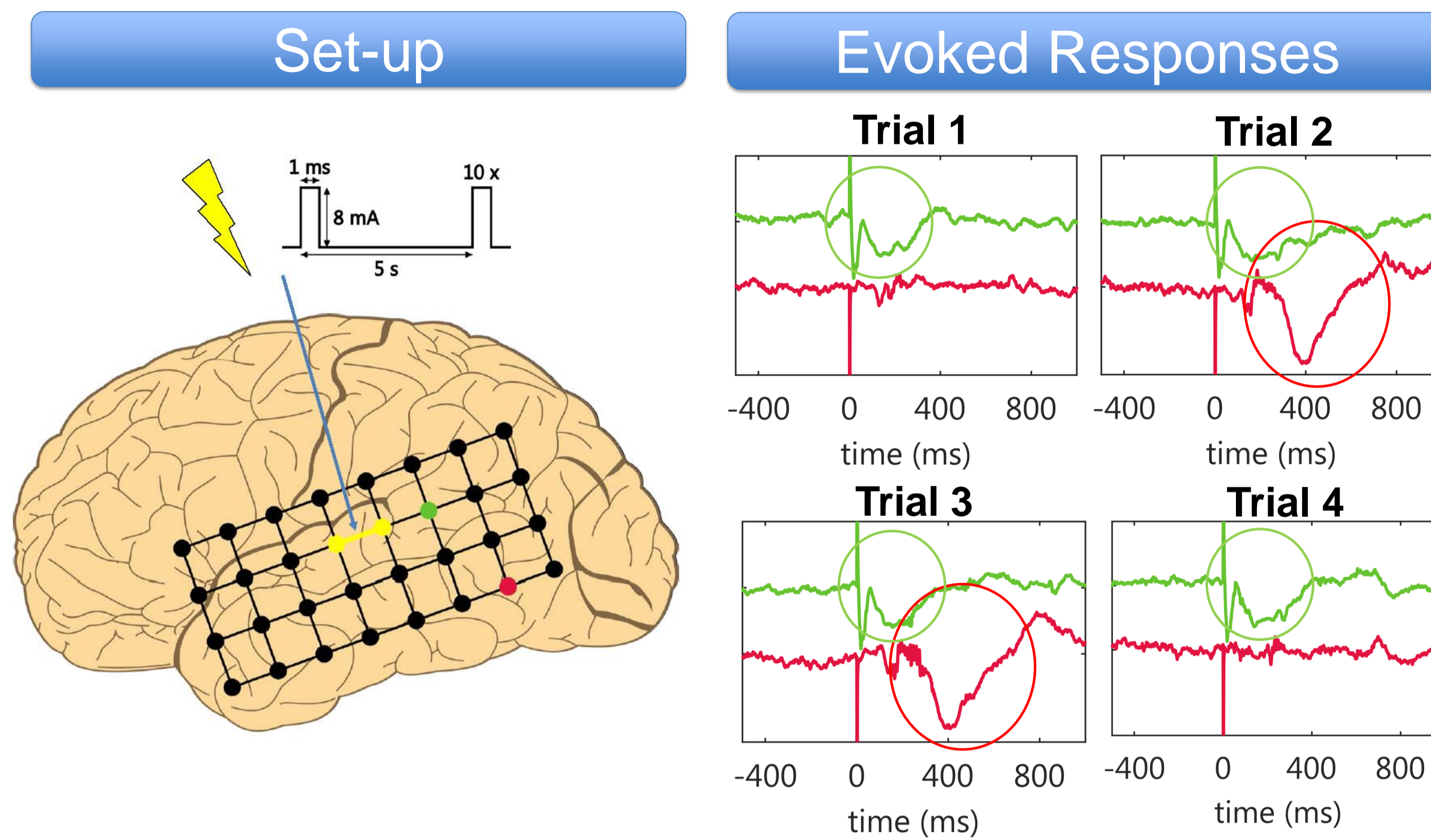
**SPES:**

- Used in pre-surgical evaluation of epilepsy patients
- Stimulation evokes physiological early and delayed responses.

**EARLIER WORK [4]:**

- Stochastic appearance of DRs as second-order response in neural mass model.

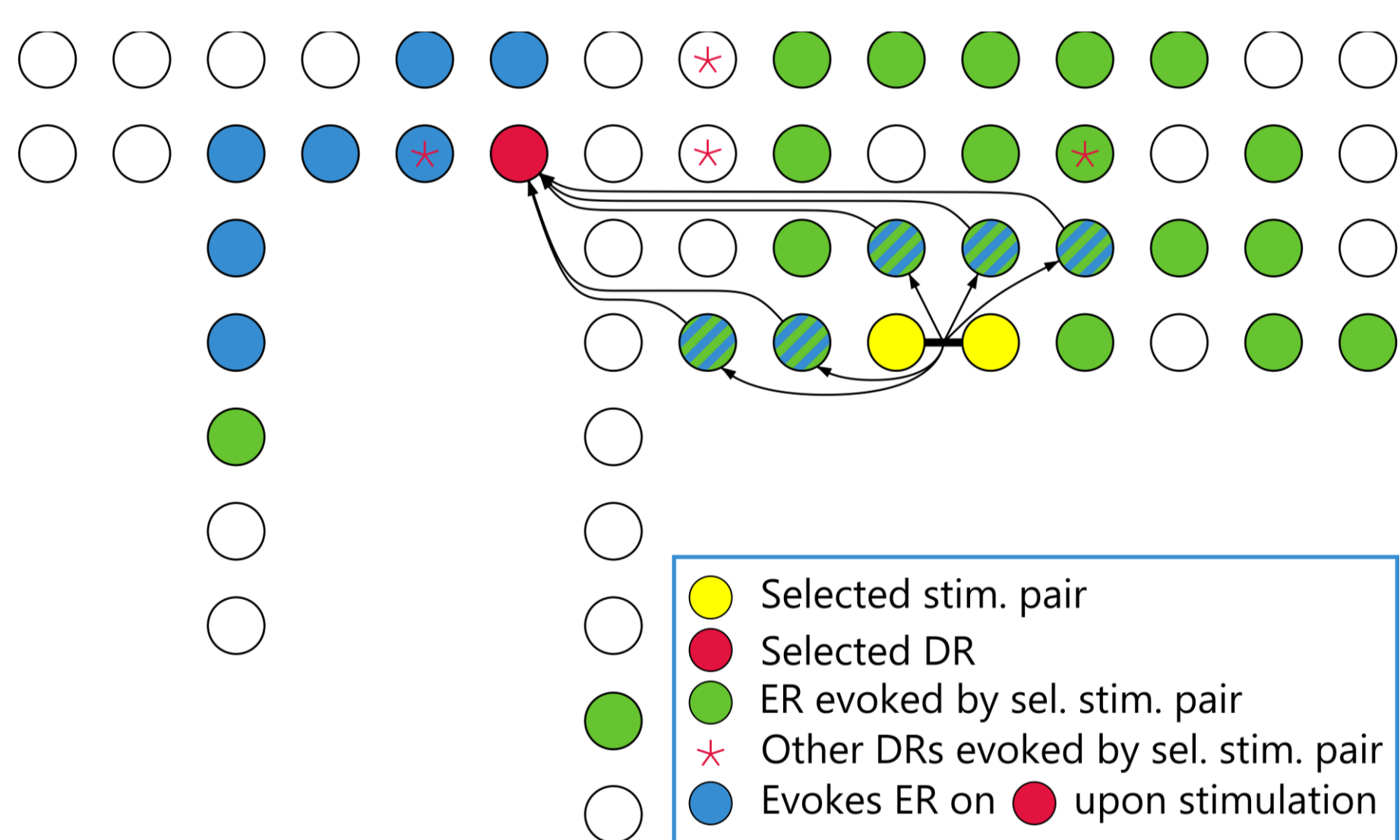
**AIM:** Fit coupled neural masses model to reproduce response data to explore patients' seizure evolution and eventually surgery.



- ER** Early Response
- Onset < 100 ms after stimulation
  - Consistent appearance
  - Defines effective connectivity [1]
- DR** Delayed Response
- Onset 100-1000 ms after stimulation
  - Stochastic appearance
  - Associated with epilepsy [2]

## Modelling Responses

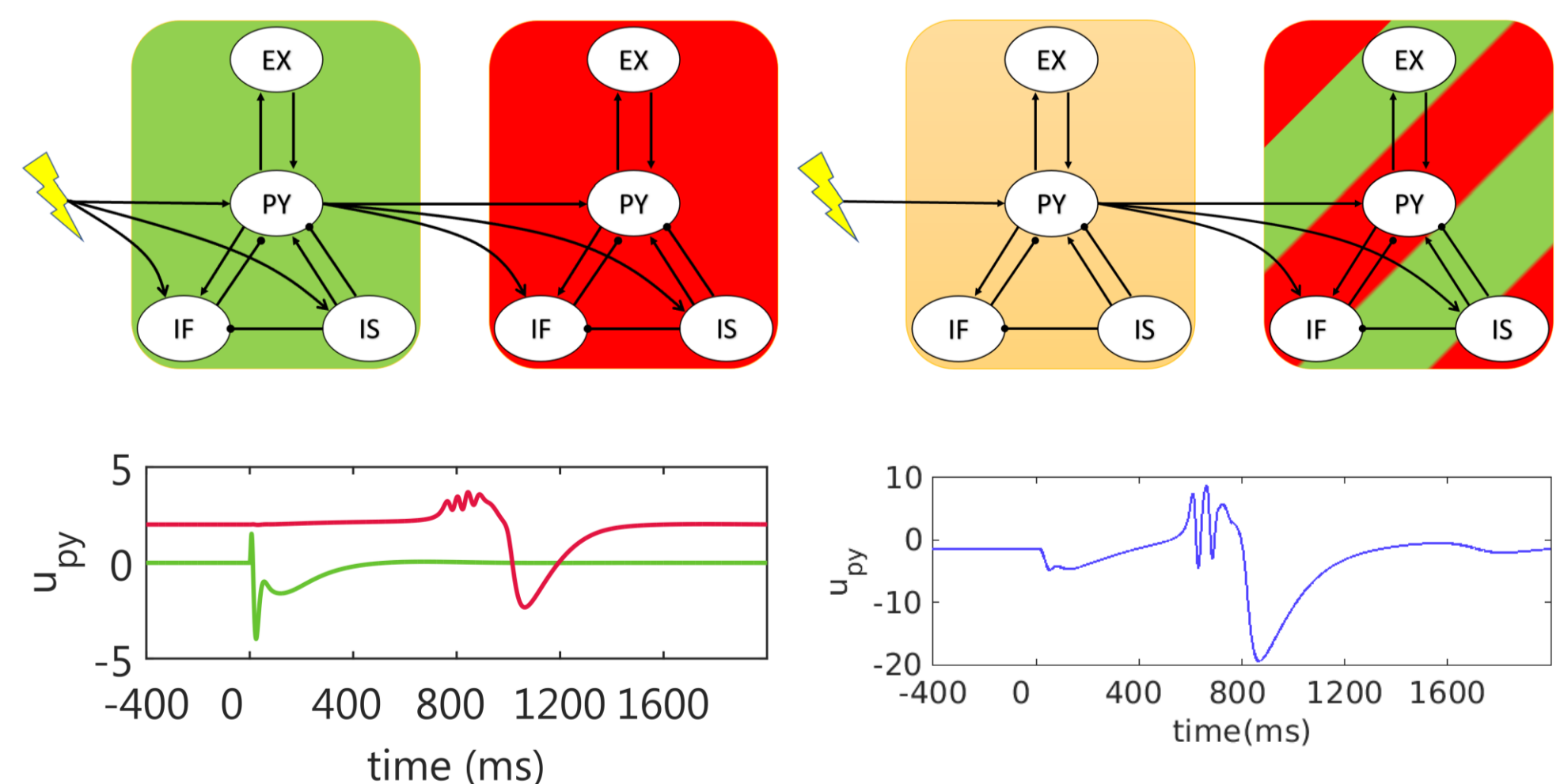
Exemplary stimulation response



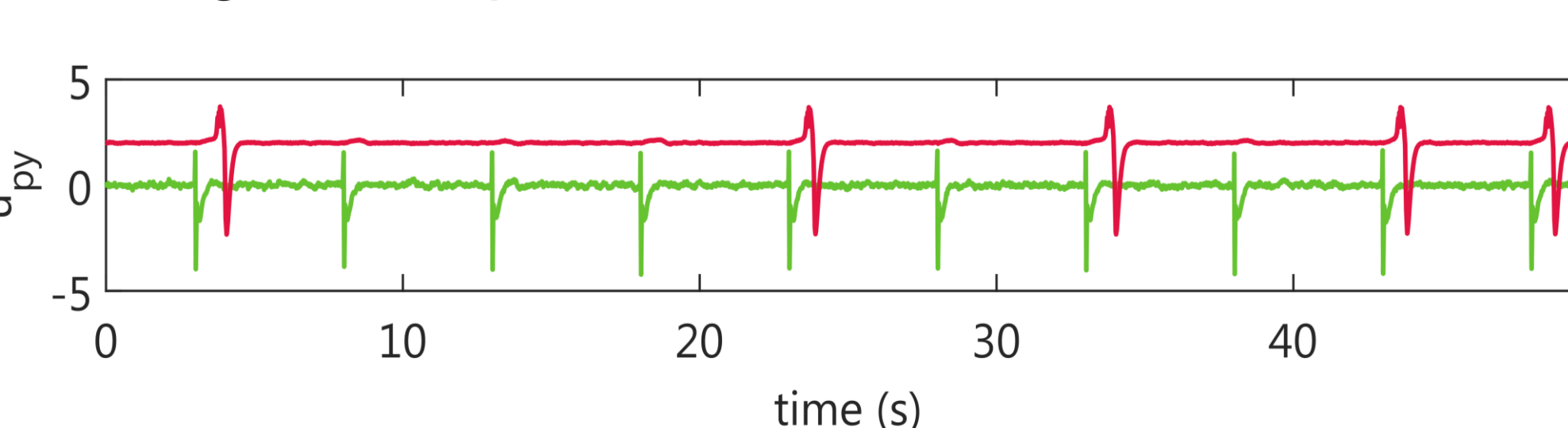
- First and second-order paths characterize ~90% of DRs requiring short network motifs only.
- Use coupled neural masses [3] and stimulation to evoke responses. NM parameters fitted to ERs, network parameters vary.

Only DR in node #2

Both ER+DR in node #2



Background input noise leads to stochastic DRs.

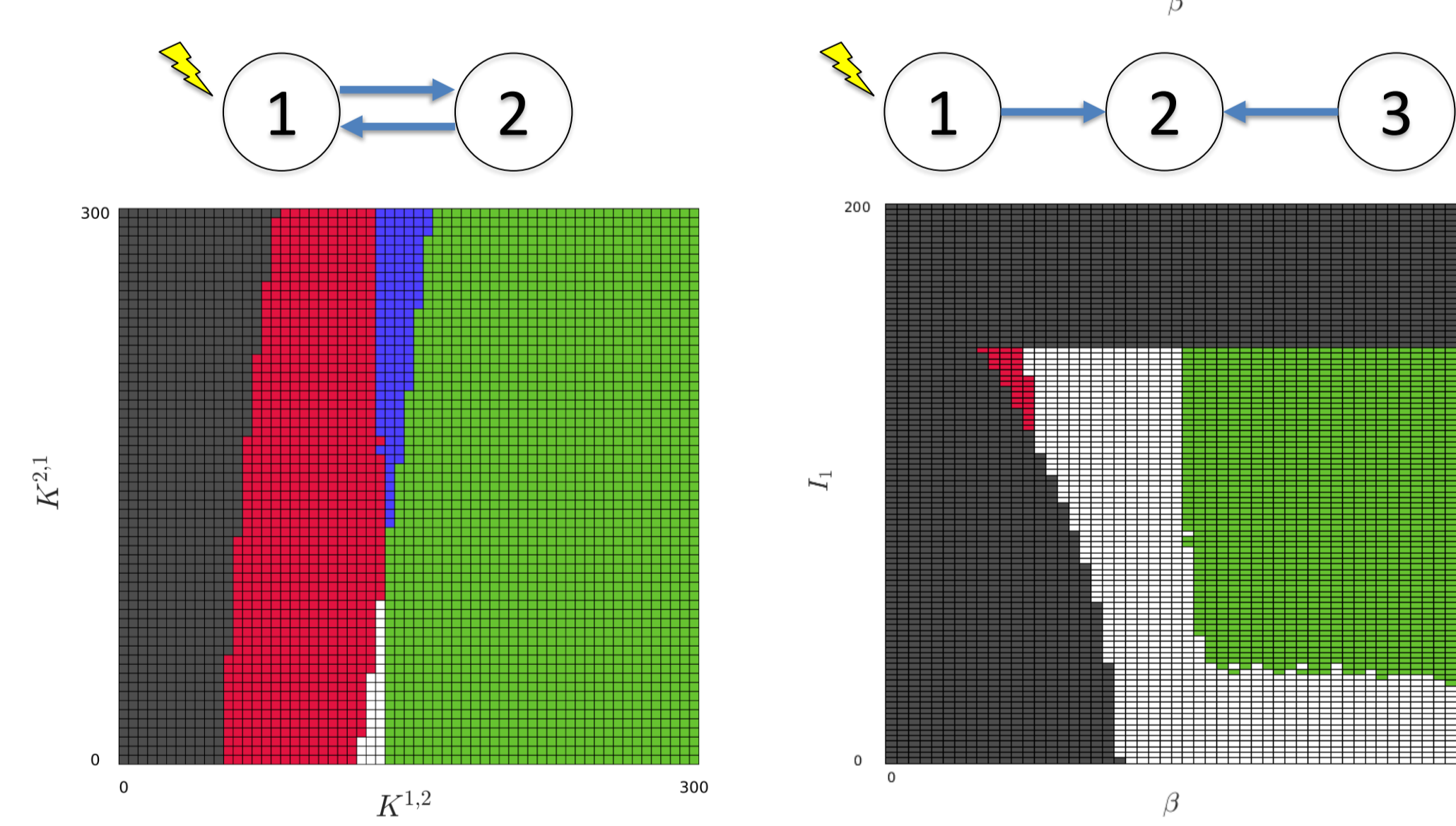


## Network Parameter Effects

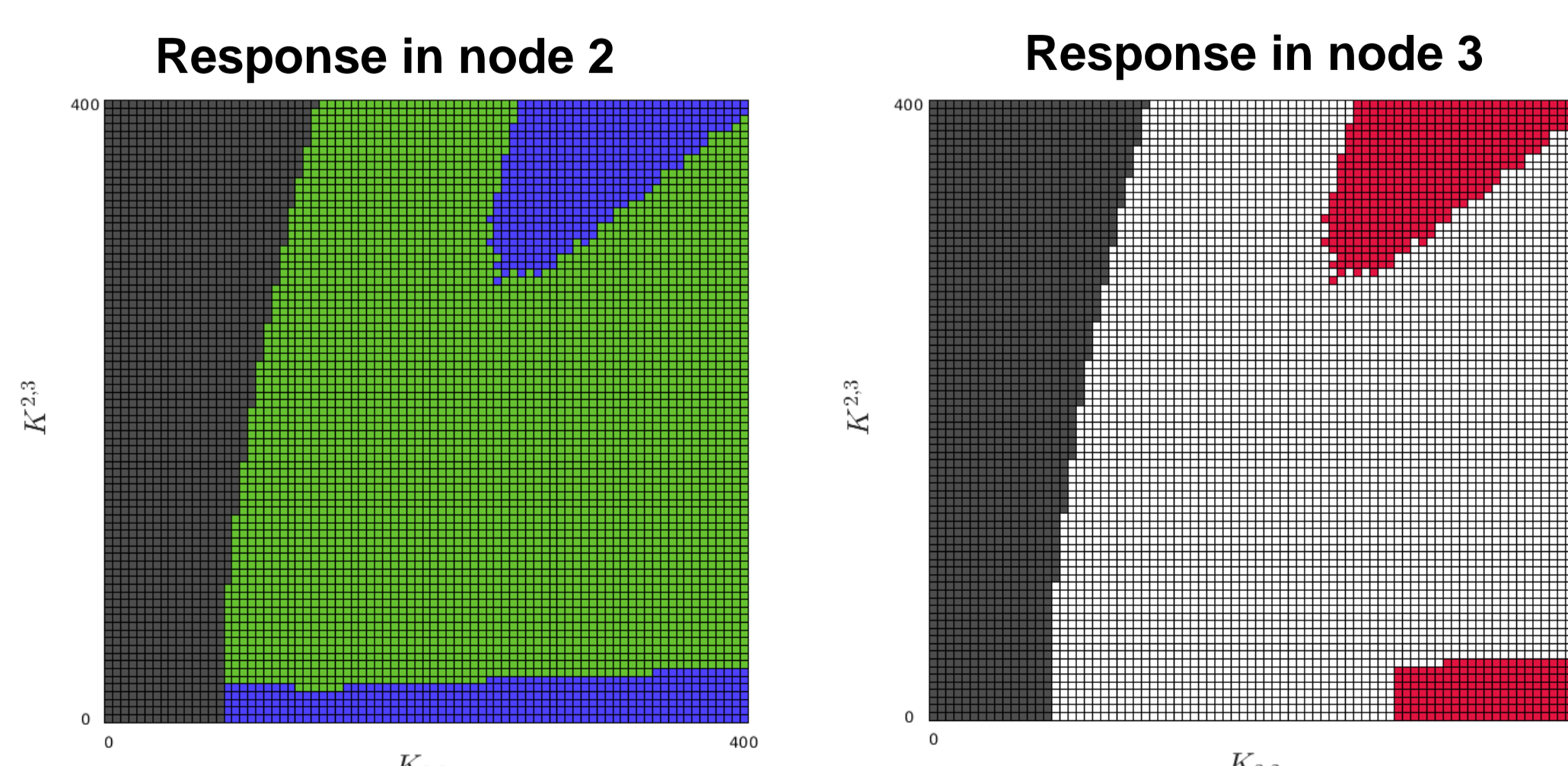
**Method:** Simulate with systematic variations of coupling strength  $K_{i,j}$ , background input  $I_i$  and feedforward inhibition  $\beta$  for relevant network motifs and characterize amplitude for ERs and ripple+spike for DRs in Node #2.

**Legend:**  
 White No response  
 Gray Oscillations  
 Green ER  
 Red DR  
 Blue ER + DR

**Result:**  
 Parameter variation indeed allows tuning responses



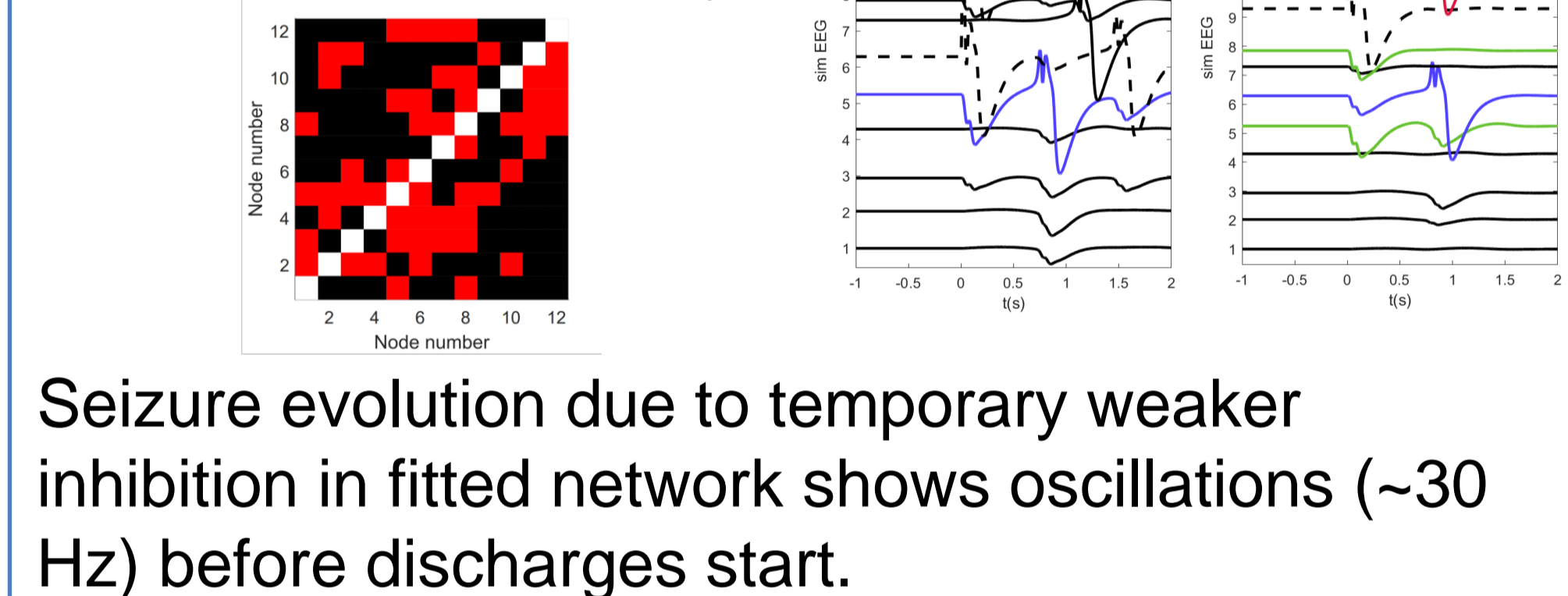
Higher-order ER is not likely to happen.



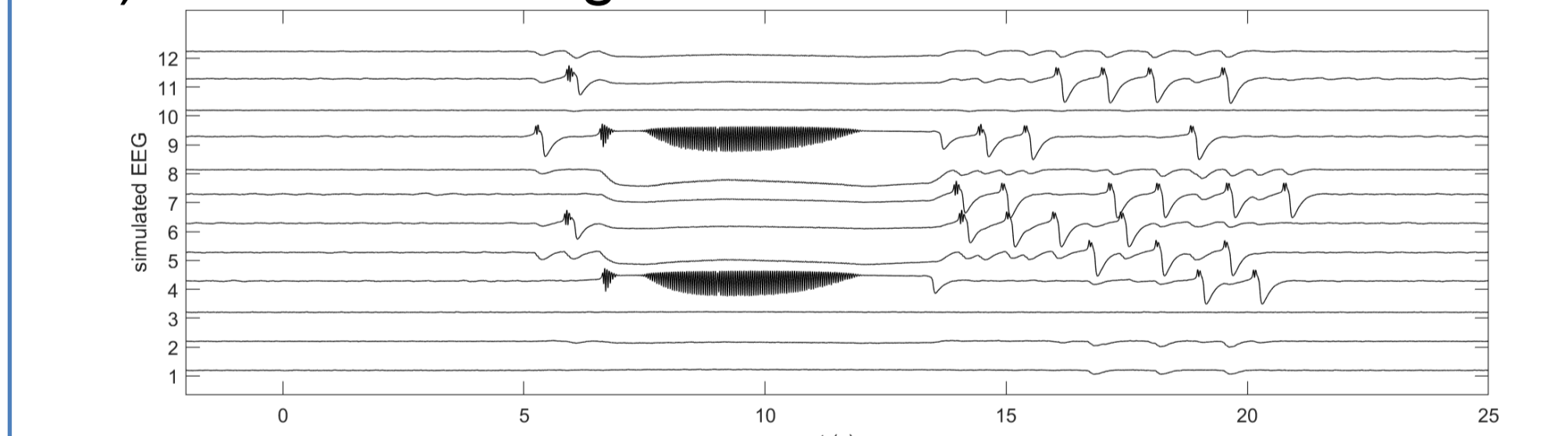
## Network Fitting Results

**Method:** Differential evolution to optimize network parameters. Cost function to promote correct responses and to avoid incorrect responses and background oscillations.

**Test:** 12 artificial 4x3 grids with known connectivity



Seizure evolution due to temporary weaker inhibition in fitted network shows oscillations (~30 Hz) before discharges start.



12 Artificial Networks	Early Responses			Delayed Responses		
	#found	#desired	#false	#found	#desired	#false
#1	14	15	1	6	9	0
#2	11	11	1	4	10	0
All (Sum)	132	134	6	86	90	2

4 Patient Networks	Early Responses			Delayed Responses		
	#found	#desired	#false	#found	#desired	#false
#1	697	701	28	0	313	0
#2	613	624	39	1	247	0
#3	218	292	14	7	251	1
#4	646	663	46	10	589	1

**CONCLUSION:** Inferring physiological effectivity connectivity is feasible. Fitting delayed responses requires more work on parameter variations and stochasticity.

**REFERENCES**

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