# Automated design of fMRI paradigms

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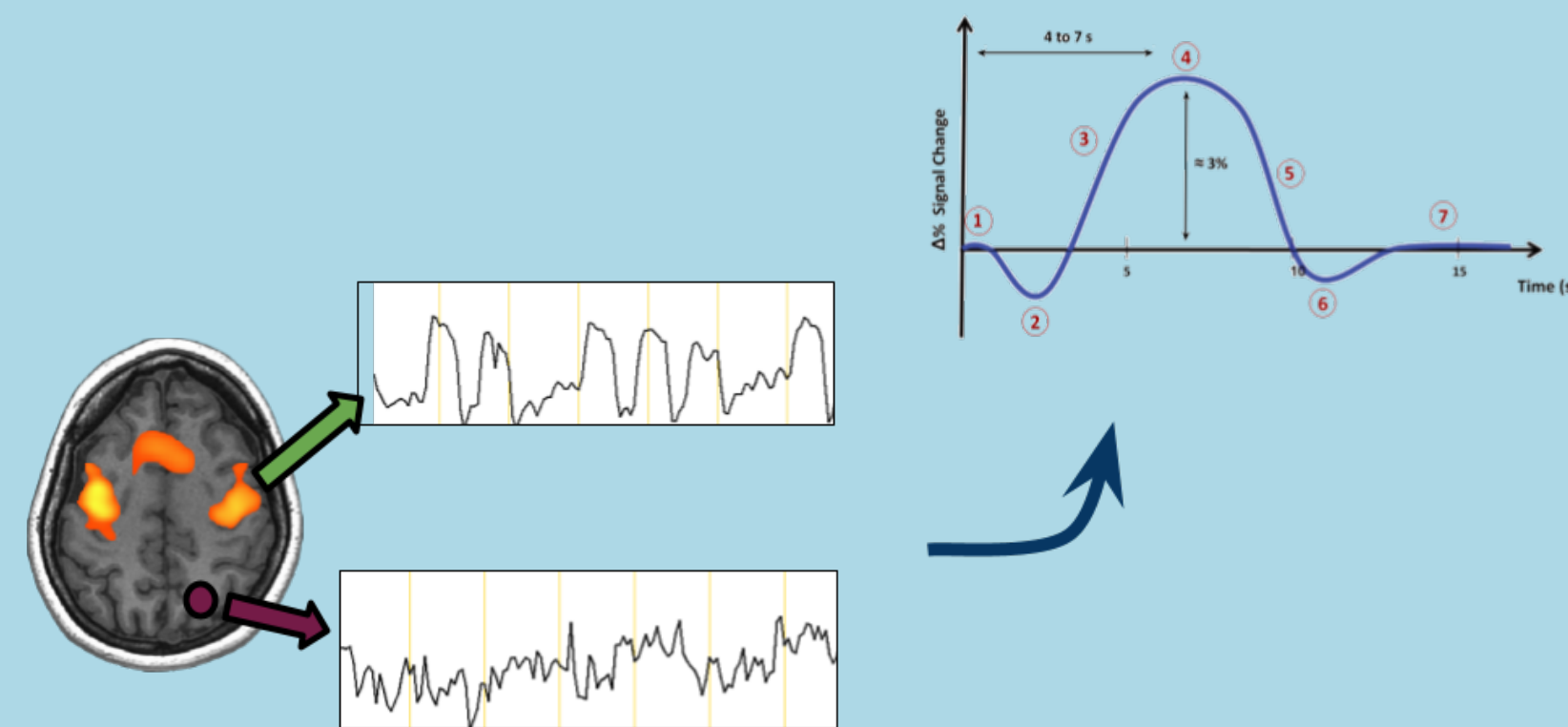
## Motivation

### Functional MRI

Funcional Magnetic Resonance Imaging (fMRI)

- Neuroimaging techniques to **assess brain activation** patterns;
- fMRI experiments rely on the precise and effective paradigm design, selecting **the best sequences of stimuli** to activate specific brain regions.

fMRI scans yield a Blood Oxygen Level Dependent (BOLD) signal
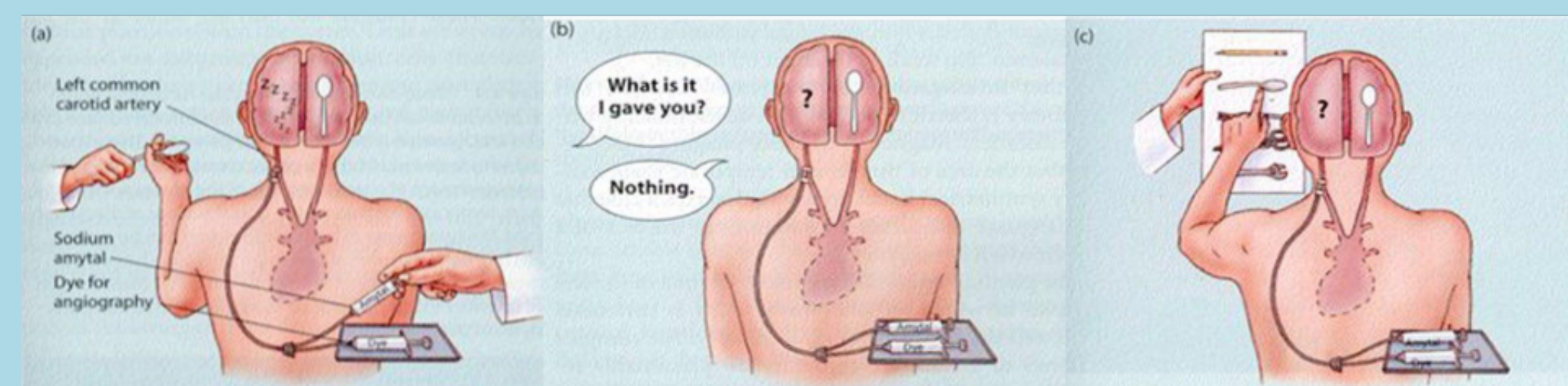


### Paradigm

- Activities performed or stimuli received by the subject during a study to evoke a brain activation in certain brain areas.
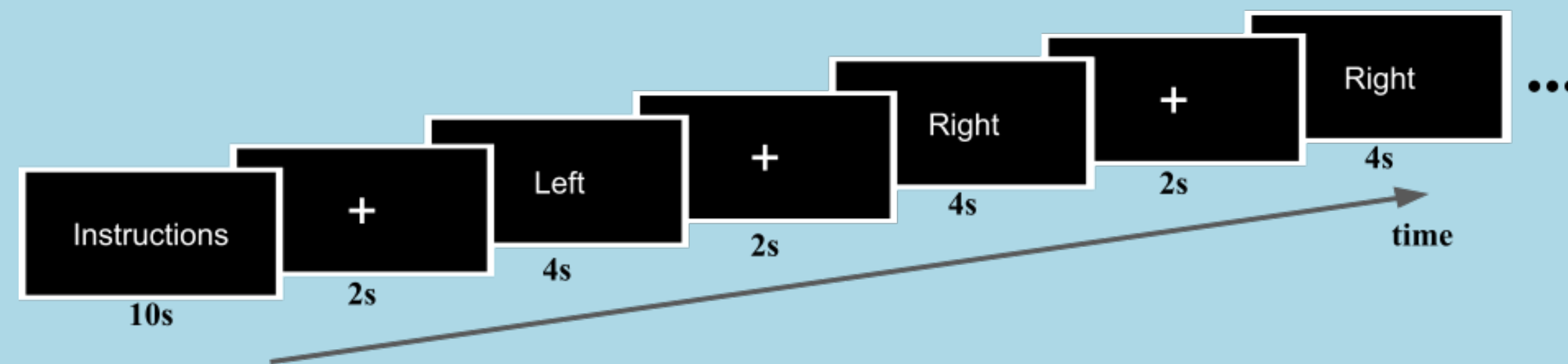


**Key Challenge:** design paradigms from scratch for neuroimage studies and presurgical planning.
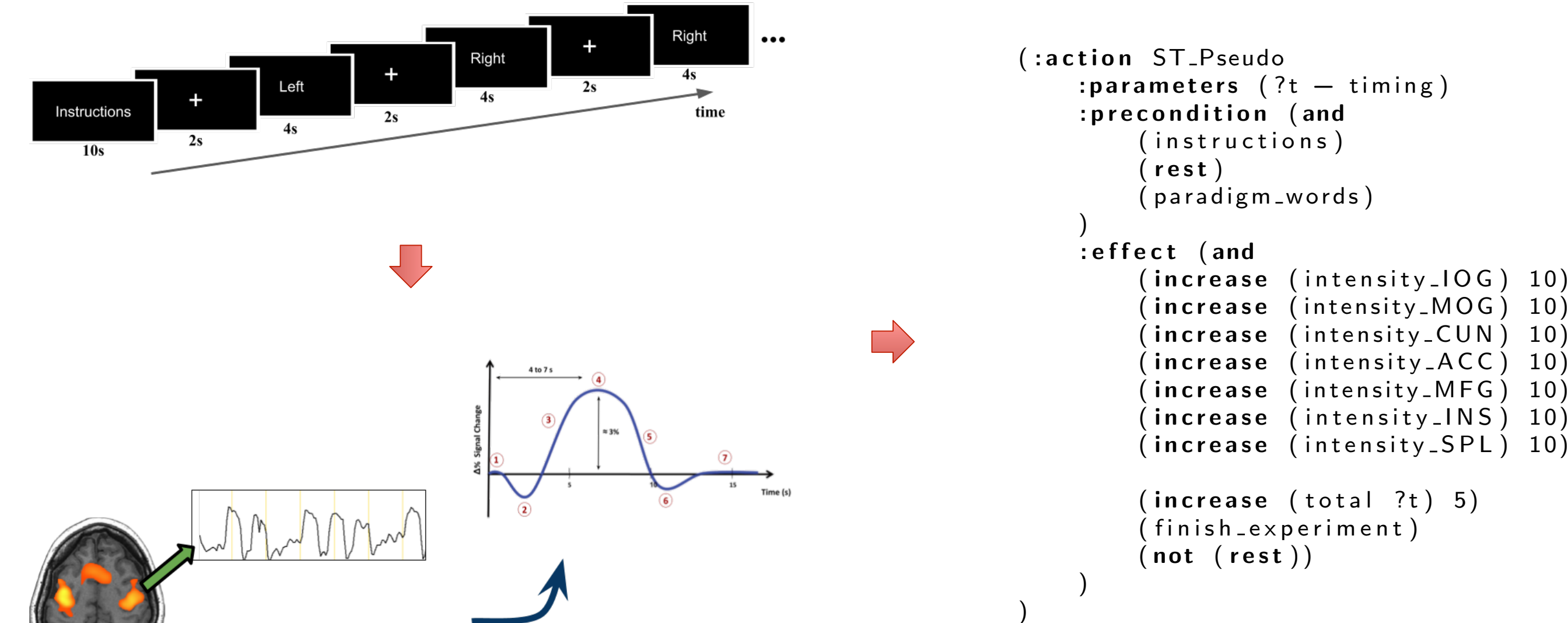
### Presurgical Planning

- Localization of important cortical and subcortical areas at risk of injury during the surgical removal of brain lesions;
- Important to avoid permanent damage to neurological function;
- Preoperative counseling:
  - Brain tumor, vascular lesions, intractable epilepsy, and other resectable lesions.



## A PDDL+ Formalization of fMRI

Key Goal, fMRI activation model in PDDL+



```
(:action ST_Pseudo
  :parameters (?t - timing)
  :precondition (and
      (instructions)
      (rest)
      (paradigm_words)
  )
  :effect (and
      (increase (intensity_IOG) 10)
      (increase (intensity_MOG) 10)
      (increase (intensity_CUN) 10)
      (increase (intensity_ACC) 10)
      (increase (intensity_MFG) 10)
      (increase (intensity_INS) 10)
      (increase (intensity_SPL) 10)

      (increase (total ?t) 5)
      (finish_experiment)
      (not (rest))
  )
)
```

Applications of the model:
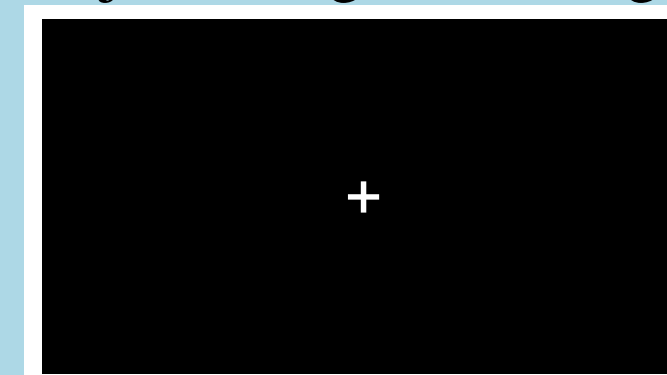- Neuroscience research design
- Pre-surgical planning

### Formalization: Predicates

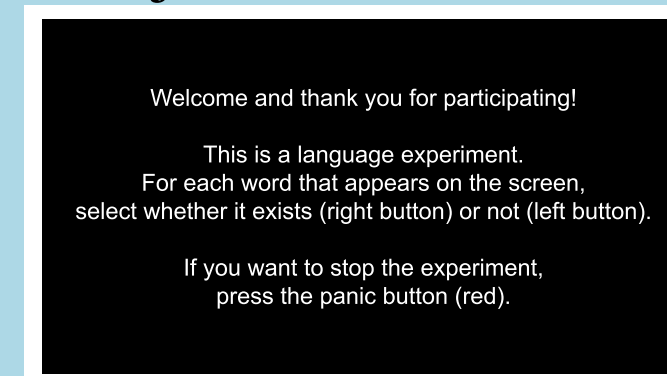Numeric activation intensities for each anatomic region:
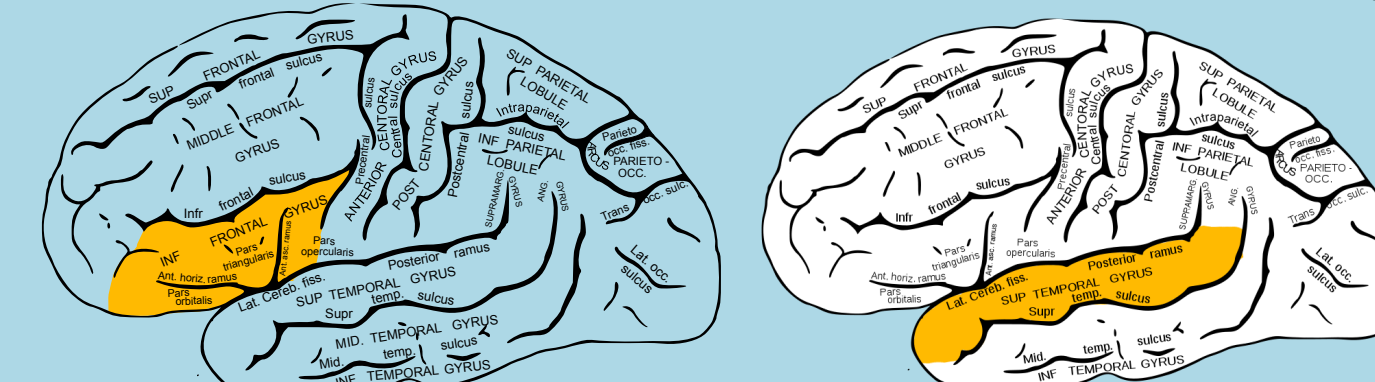


(intensity_IFG),(intensity_STG)

Whether the subject has gone through a *rest* period:



(rest)

Whether the subject has visualized *instructions*:



(instructions)

### Formalization: Actions

- Instructions
- Baseline Rest
- Stimuli



## Experiments

**Automated Planning for Presurgical Planning**

Experiment 1 - Left Inferior Frontal Gyrus
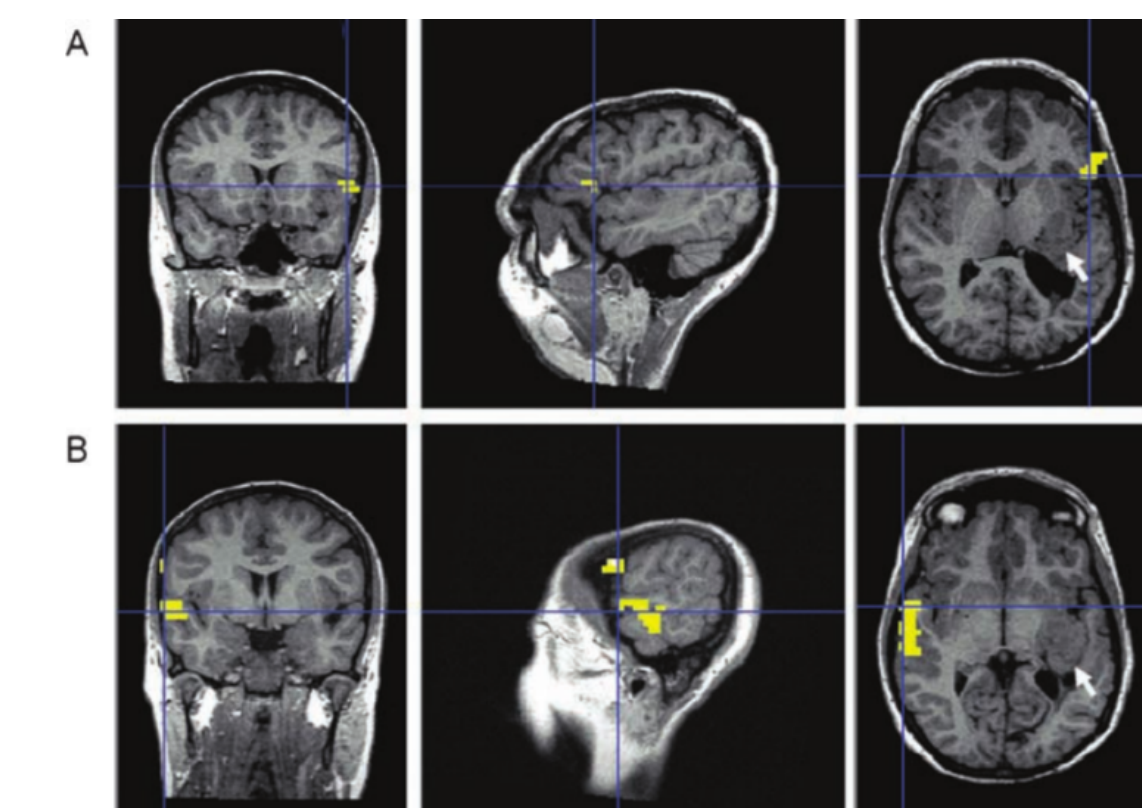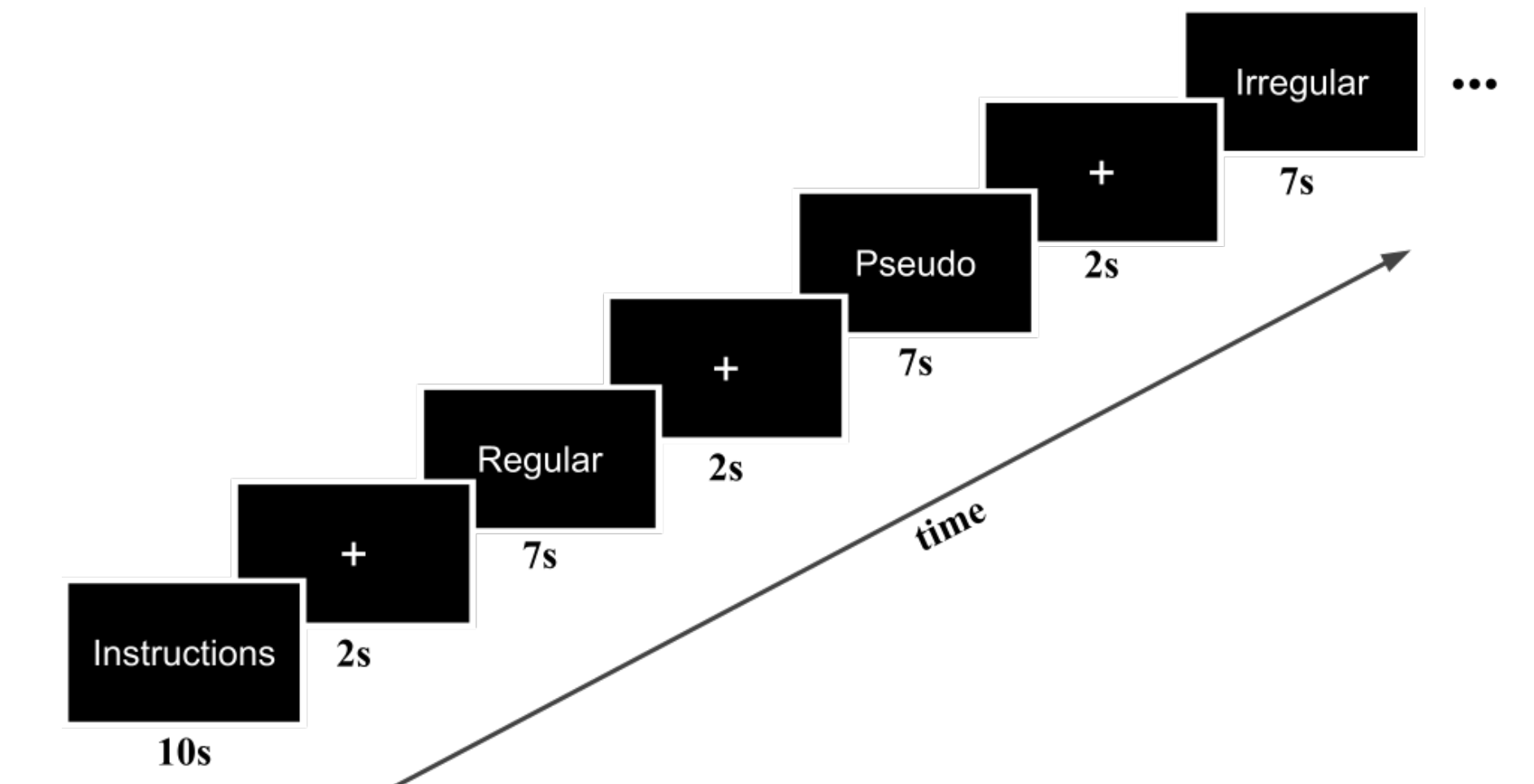**Planner's Goal:** $intensity(LIFG) >= 100$





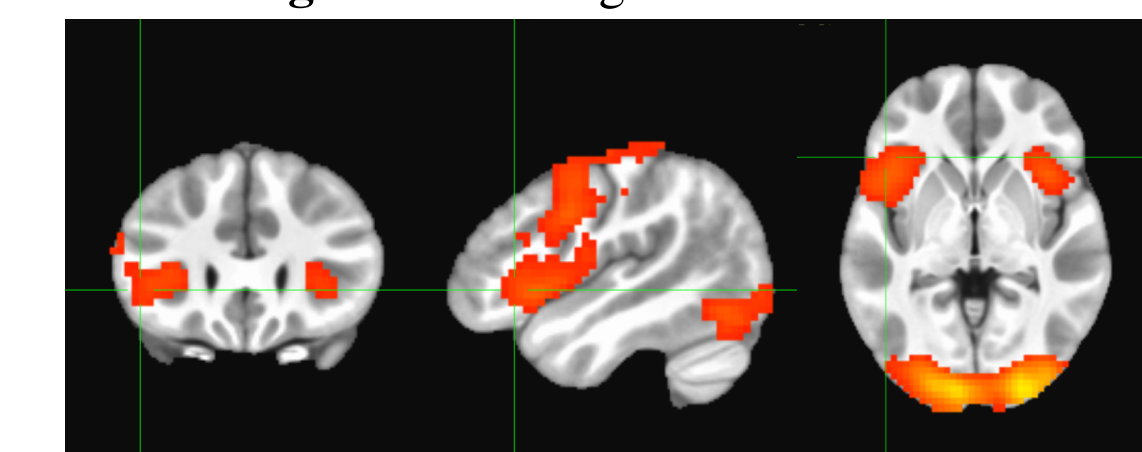**Figure 1:** Presurgical clinical case



**Figure 2:** Our paradigm planner

## Conclusions and Perspectives

- We developed a specific application in PDDL+ to **planning neuroimaging paradigms**
  - aimed at solving the dual problem of effective paradigm design and scan cost minimization;
- Potentially useful tool for **Neuroscientific Research** and as a supporting resource for presurgical planning;
- Moving forward:
  - General method to derive activation values (e.g. ML);
  - Linearization of non-linear activation functions.

Code available at:
https://bit.ly/fmri-pddl