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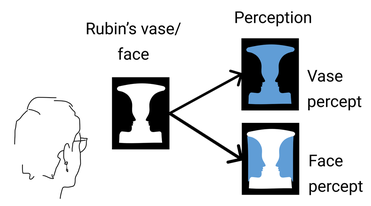
Multistability: Physiological 'signature' of perceptual changes in ambiguous vision

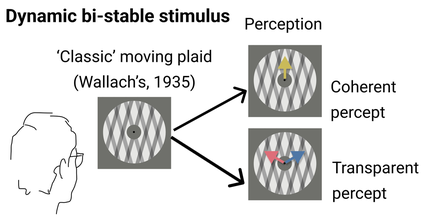
Juliette Lenouvel, Ronald Phlypo, Alan Chauvin, Michele Rombaut. Thesis fund by Initiatives de Recherche Stratégiques (IRS), IDEX Grenoble Alpes University.
To contact the author juliette.lenouvel@gipsa-lab.grenoble-inp.fr
Univ. Grenoble Alpes, CNRS, Grenoble INP, GIPSA-lab (institute of engineering Univ. Grenoble Alpes). Univ. Grenoble Alpes, CNRS, LPNC.

MULTI-STABLE STIMULI:

Static bi-stable stimulus

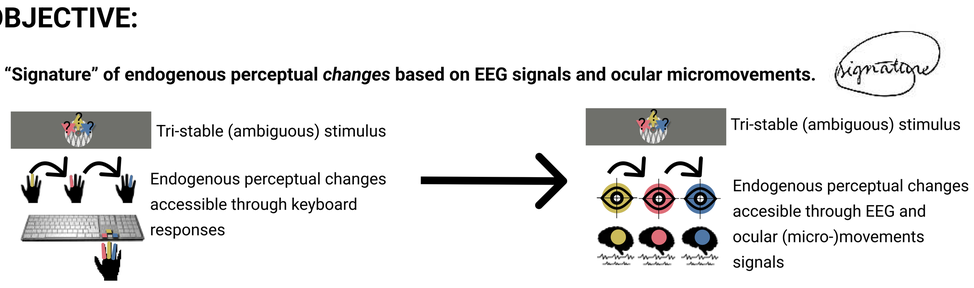


Dynamic bi-stable stimulus

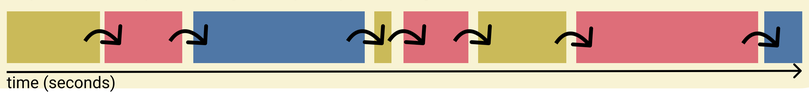


OBJECTIVE:

- **"Signature" of endogenous perceptual *changes* based on EEG signals and ocular micromovements.**

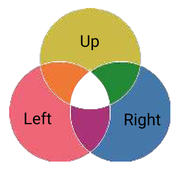


- **Model of multi-stable perception:**
  - **Descriptive**: model dynamics of observed endogenous perceptual *changes*
  - **Predictive:** predict and explain endogenous perceptual *changes*



LEGEND:

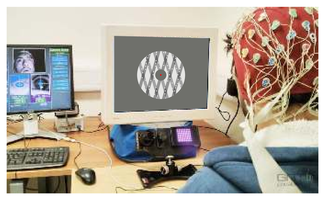
Color coded percepts/keys pressed



Monostable (Unambiguous) signals change. Exogenous change

Tri-stable (Ambiguous) signal unchange. Endogenous change

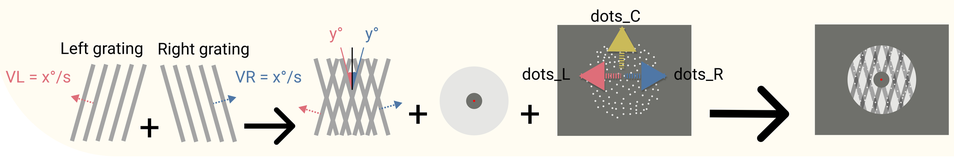
DATA COLLECTION:



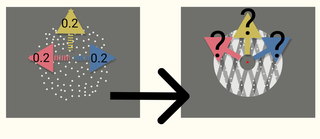
- **Eye-tracking** to obtain eye movement datas
- **EEG** (electroencephalogram) to obtain the brain's electrical activity
- **Keyboard responses** to obtain participant's response (their percept)

PLAID CREATION

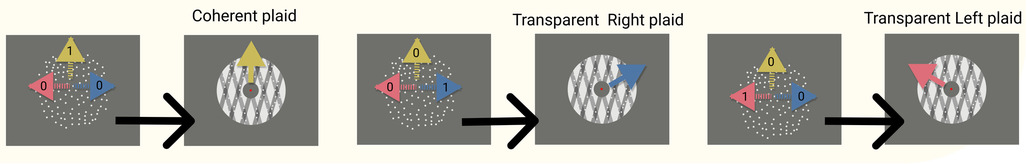
- Gratings have opposite directions but the same velocity.
- Noise dots follow a constant, more or less random direction. It depends on coherency value, between 0 (all random) and 1 (not random at all).



Ambiguous (tri-stable) plaid creation.
1 signal, 3 possible percepts: lines move upward, to the right or to the left.



Unambiguous (monostable) plaids creation.
1 signal, 1 possible percept for each plaid. Coherent plaid: percept lines move upward ; Transparent Right plaid to the right ; Transparent Left plaid to the left.

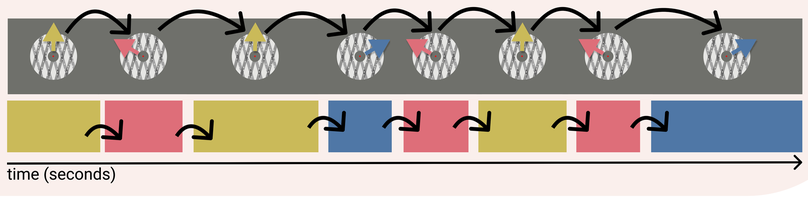


SEQUENCE GENERATION

- Perceptual history (participant's response) of an ambiguous trial feeds a model based on a semi-markov chain that learns residence time of each percept and transition matrice between percepts.
- The sequence of an unambiguous trial is created by this model.
- The model is updated at each ambiguous trial and a new sequence is generated at each unambiguous trial.

Ambiguous (tri-stable) stimulus

Unambiguous (monostable) stimulus: The sequence of unambiguous stimuli depend on perceptual histories (participant's response) of ambiguous stimuli.

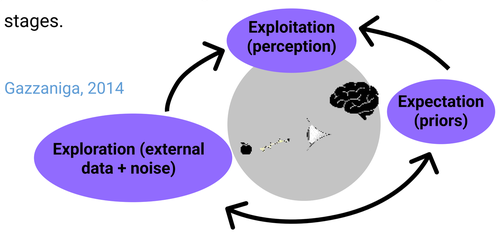


FRAMEWORK:

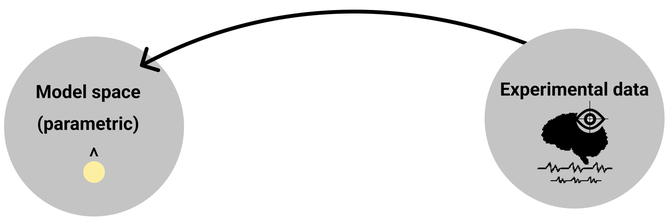
Visual perceptual system processes as an agent in reinforcement learning divided into several stages.

VanRullen, 2016

Olshausen, Mangun & Gazzaniga, 2014



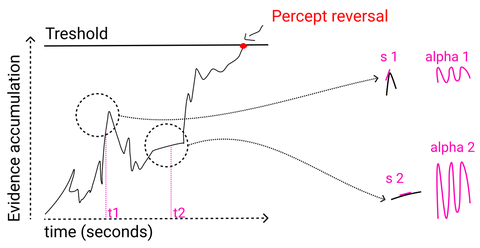
MODEL:



Example:
If a drift diffusion decision model is chosen, the value of the slope (s) at a time t depends on the amplitude of alpha at that time t.

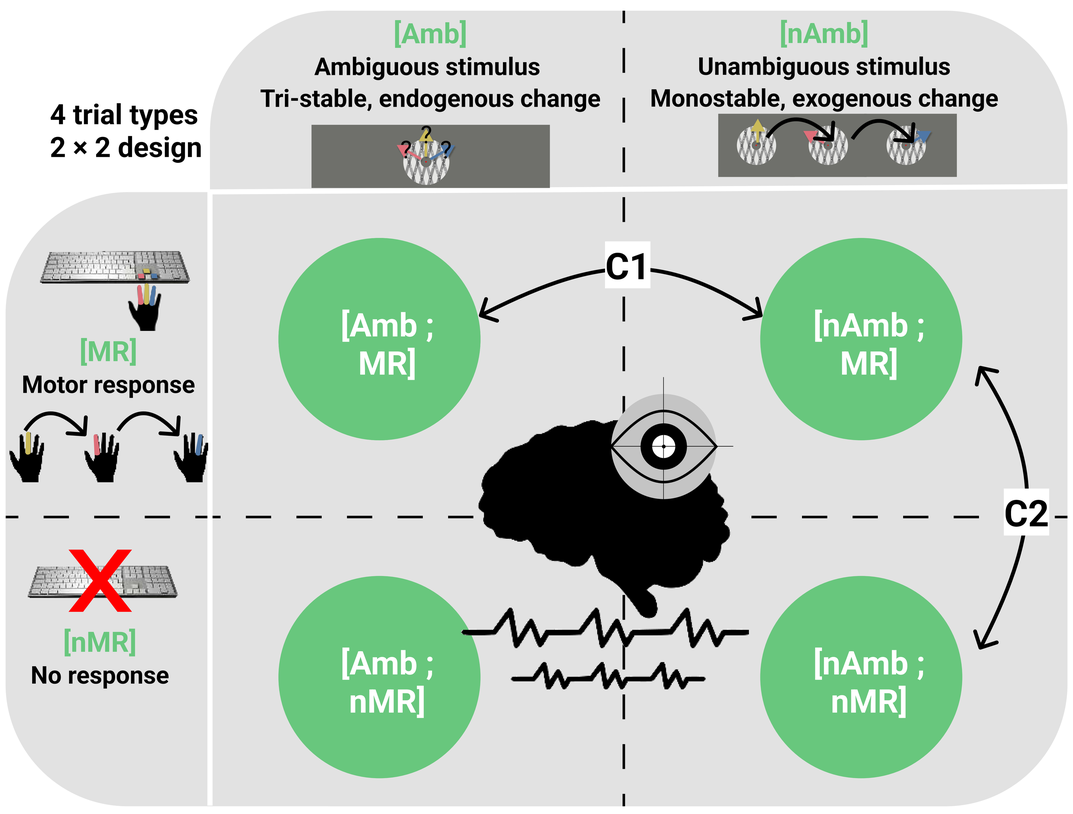
Lower alpha amplitude ---> more chance to change percept (Strüber & Herrmann, 2002).

Parameter estimation (model)



PROCEDURE

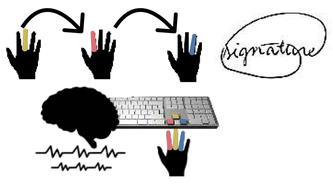
4 trial types
2 × 2 design



CONTRASTS C1:

[nAmb ; MR] VS. [nAmb ; MR]

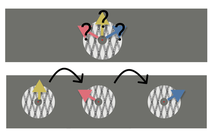
Motor signature



CONTRASTS C2:

[Amb ; MR] VS. [nAmb ; MR]

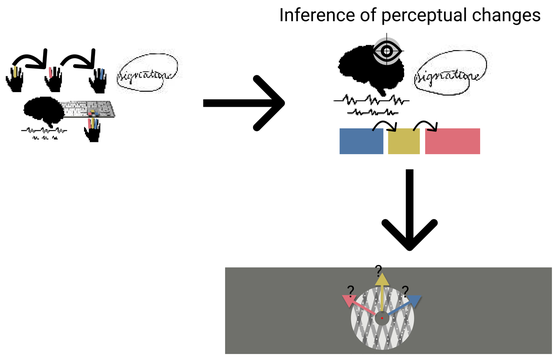
Endogeneous vs exogeneous signature



REGRESSION:

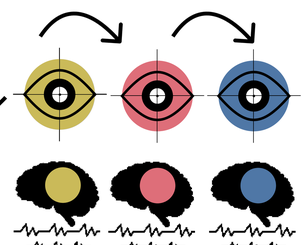
[Amb ; MR] –

Inference of perceptual changes



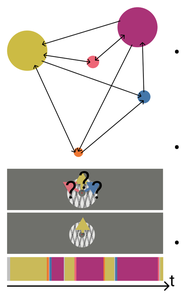
REGRESSION:

[Amb ; nMR]



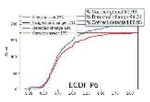
RESULTS:

Pilot 1 (22 participants). **Adaptation/facilitation mechanisms investigations and test of our previous stimuli.**



- **Process to extract 'Perceptual history'** from participant's responses: we model the perceived movement of each trial (perceptual sequences) as a Markov Renewal Process (MRP) with percepts as states. Algorithm takes into account duration and direction of percepts.
- **Stimuli limitation:** Ambiguous stimulus is not tris-table, seems bi-stable (coherent vs right/left at the same time). Coherent (Up) plaid is not unambiguous enough. Similar perceived movement (perceptual sequence) is obtained with Coherent (Up) plaid and Ambiguous plaid.
- Our results suggest that motion after effect, linked to the neural adaptation phenomeon, can be induced by percept and is not limited to mere signal adaptation. Thus, it seems that "high-level" adaptation occurs, and can be a factor of multistability.

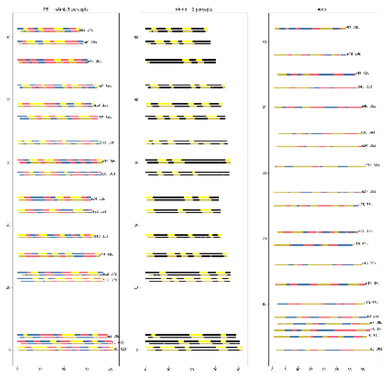
Pilot 2 (20 participants). **Stimuli correction after the result of the pilot 1**



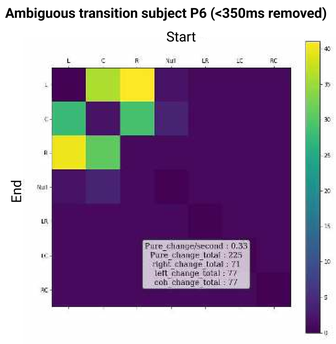
New stimuli presented in this poster.

- **Unambiguous condition:** enough changes detected and correct answers.
- **Ambiguous condition:**

1. Residence time and number of transitions between each percept are similar. Pure tri-stability not reached but very close (which is sufficient, and pure tri-stability is impossible since there is a bias for the Coherent percept, see Parisot, 2020)
2. The number of perceptual changes per participant is sufficient for our statistical studies.



Ambiguous transition subject P6 (<350ms removed)



- **Unexpected positive result:** Strong similarity between unambiguous and ambiguous conditions since participants do not distinguish them.

Subject	% Correct global	% Detected changes	% Correct among detected
P1	42%	51%	82%
P2	41%	62%	67%
P3	54%	69%	79%
P4	61%	76%	81%
P5	49%	63%	78%
P6	82%	94%	87%
P7	48%	62%	77%
P8	49%	66%	74%
P9	36%	61%	58%
P11	63%	70%	90%
P12	57%	72%	79%
P13	58%	74%	78%
P14	50%	61%	82%
P15	51%	63%	80%
P16	62%	67%	92%
P17	55%	72%	76%
P18	69%	82%	84%
P19	36%	50%	72%
P20	61%	76%	80%

CONCLUSION:

- Multi-stable plaid almost tri-stable created. Monostables equivalent (non ambiguous plaid) created.
- Unexpected positive result: strong similarity between unambiguous and ambiguous conditions. Participants did not seem to consciously distinguish endogenous from exogenous changes --> useful for futur researches in consciousness.
- Signature of endogenous perceptual changes useful for future 'No report paradigm'.

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