

## Workshop 3

Navigating the latest advancements in c-VEP BCI  
From experimental paradigms to decoding techniques

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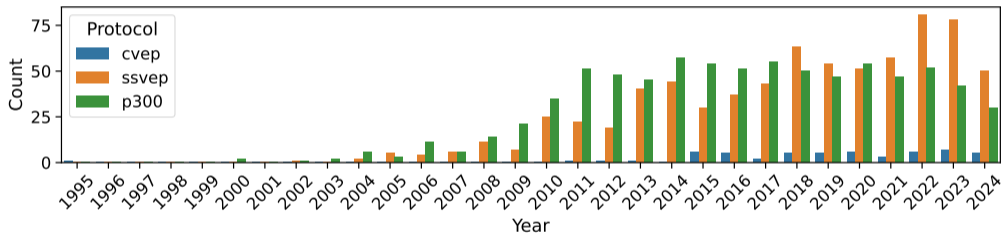
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# Code-modulated visual evoked potentials (c-VEP)?

Disclaimer: not an accurate analysis!



# Code-modulated visual evoked potentials (c-VEP)?

[Shi et al. (2024) *NeuroImage*]

- Online copy-spelling ITR of 366 bits/min
- Online free-spelling ITR of **223 bits/min**

[Miao et al. (2024) *Expert Syst Appl*]

- Under **1 min calibration** using transfer learning
- Online copy-spelling ITR of 193 bits/min
- Online free-spelling ITR of **250 bits/min**

At least two dominant reasons for good performance:

- Optimized and fast [stimulus protocol](#)
- Sophisticated [decoding techniques](#)

- **(Spontaneous) oscillations**

- Not time-locked, internally generated (endogenous)
- Change in power at a specific frequency, e.g., SMR



- **Evoked responses**

- Time-locked to an external event (exogenous)
- Change in amplitude at a specific latency, e.g., P300



[Blankertz (2014) BBCI Winter School]

- **Transient responses**

- Response to a *single* event
- Protocol: e.g., oddball
- Examples: P300, VEP, ERN, MMN

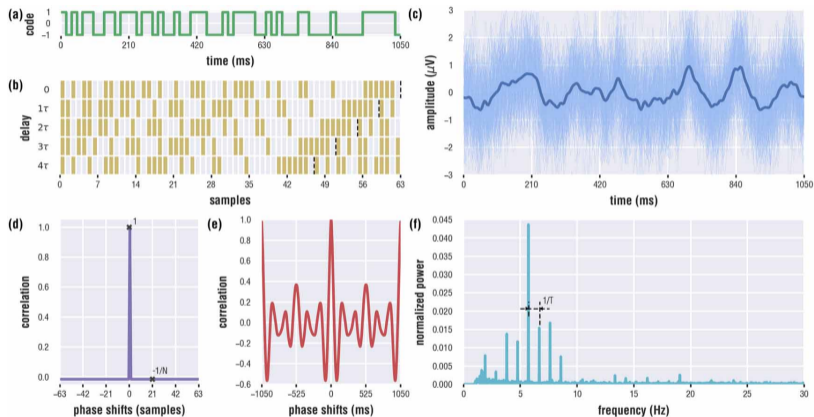
- **Steady-state responses**

- Response to *periodic* sequence of events
- Protocol: frequency-tagging, JFPM
- Examples: SSVEP, ASSR, SSSEP

- **Broad-band responses**

- Response to *pseudo-random* sequence of events
- Protocol: noise-tagging
- Examples: c-VEP, c-AEP, c-SEP

# Code-modulated visual evoked potential (c-VEP)



[Martinez-Cagigal et al. (2021) *J Neural Eng*]

# Today's workshop

09:00 - 09:05	Welcome and introduction	Jordy Thielen
	<b>Experimental Paradigms</b>	
09:05 - 09:20	Burst codes	Frédéric Dehais
09:20 - 09:35	Non-binary codes	Víctor Martínez-Cagigal
09:35 - 09:50	Auditory noise tagging	Hanneke Scheppink
09:50 - 10:00	Discussion	
10:00 - 10:10	Break	
	<b>Decoding Techniques</b>	
10:10 - 10:25	Reconvolution and zero-training	Jordy Thielen
10:25 - 10:40	Deep learning	Eduardo Santamaría Vázquez
10:40 - 10:55	Riemannian decoding	Sébastien Velut
10:55 - 11:05	Discussion	
11:05 - 11:15	Break	
	<b>Demos</b>	
11:15 - 11:25	Flickers on Top / Timeflux	Pierre Clisson, Frédéric Dehais, Sébastien Velut
11:25 - 11:35	Medusa BCI	Víctor Martínez-Cagigal, Eduardo Santamaría Vázquez
11:35 - 11:40	PyNTBCI / Dareplane	Hanneke Scheppink, Jordy Thielen
11:40 - 12:00	Live demos	