1. Цель работ отдела нейрокогнитивных технологий

Повышение эффективности деятельности человека на основе нейрокогнитивных технологий.

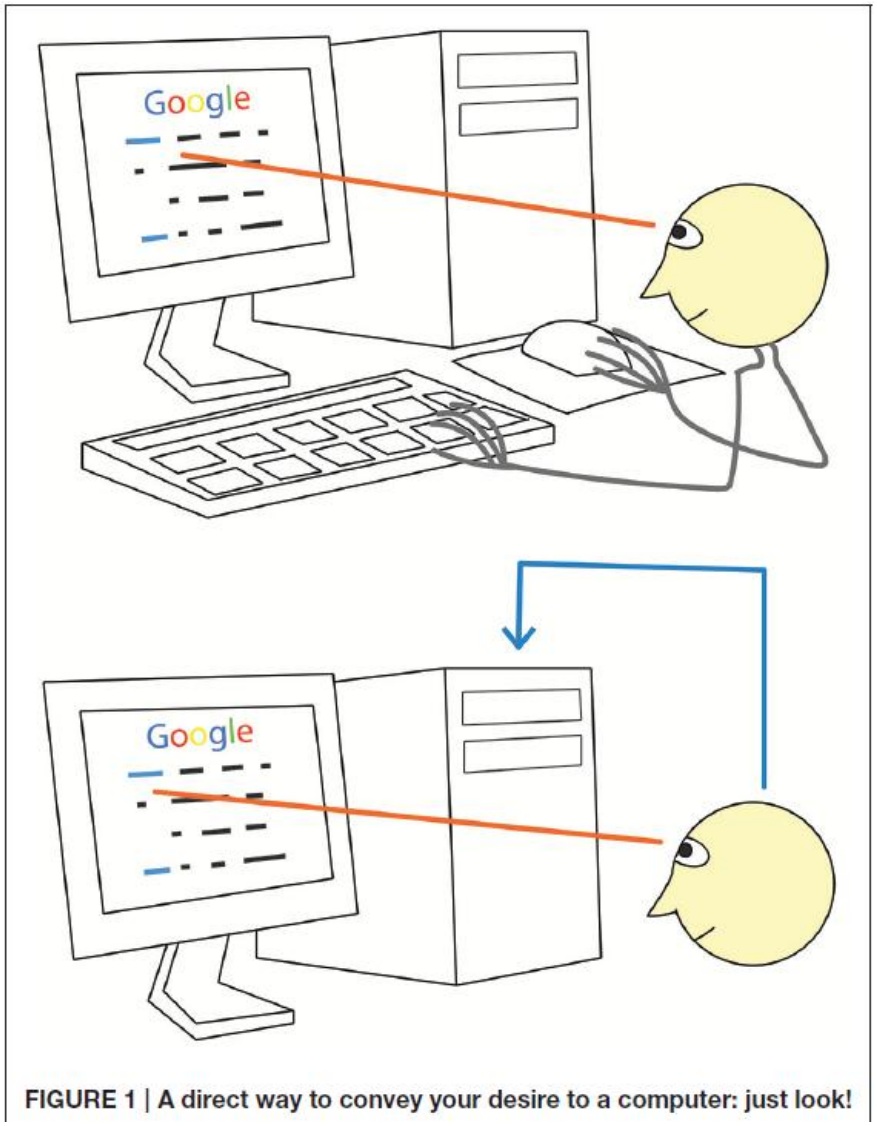

FIGURE 1 | A direct way to convey your desire to a computer: just look!

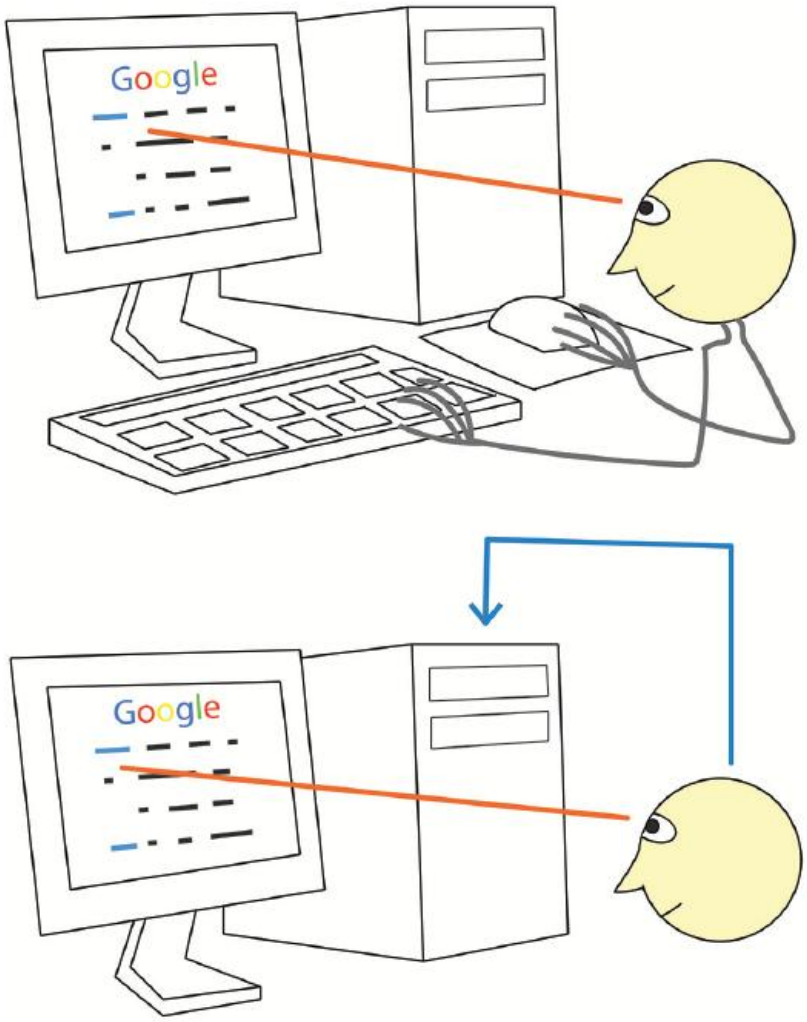

FIGURE 1 | A direct way to convey your desire to a computer: just look!

ORIGINAL RESEARCH ARTICLE
Front. Neurosci., 18 November 2016 | https://doi.org/10.3389/fnins.2016.00528

EEG Negativity in Fixations Used for Gaze-Based Control: Toward Converting Intentions into Actions with an Eye-Brain-Computer Interface

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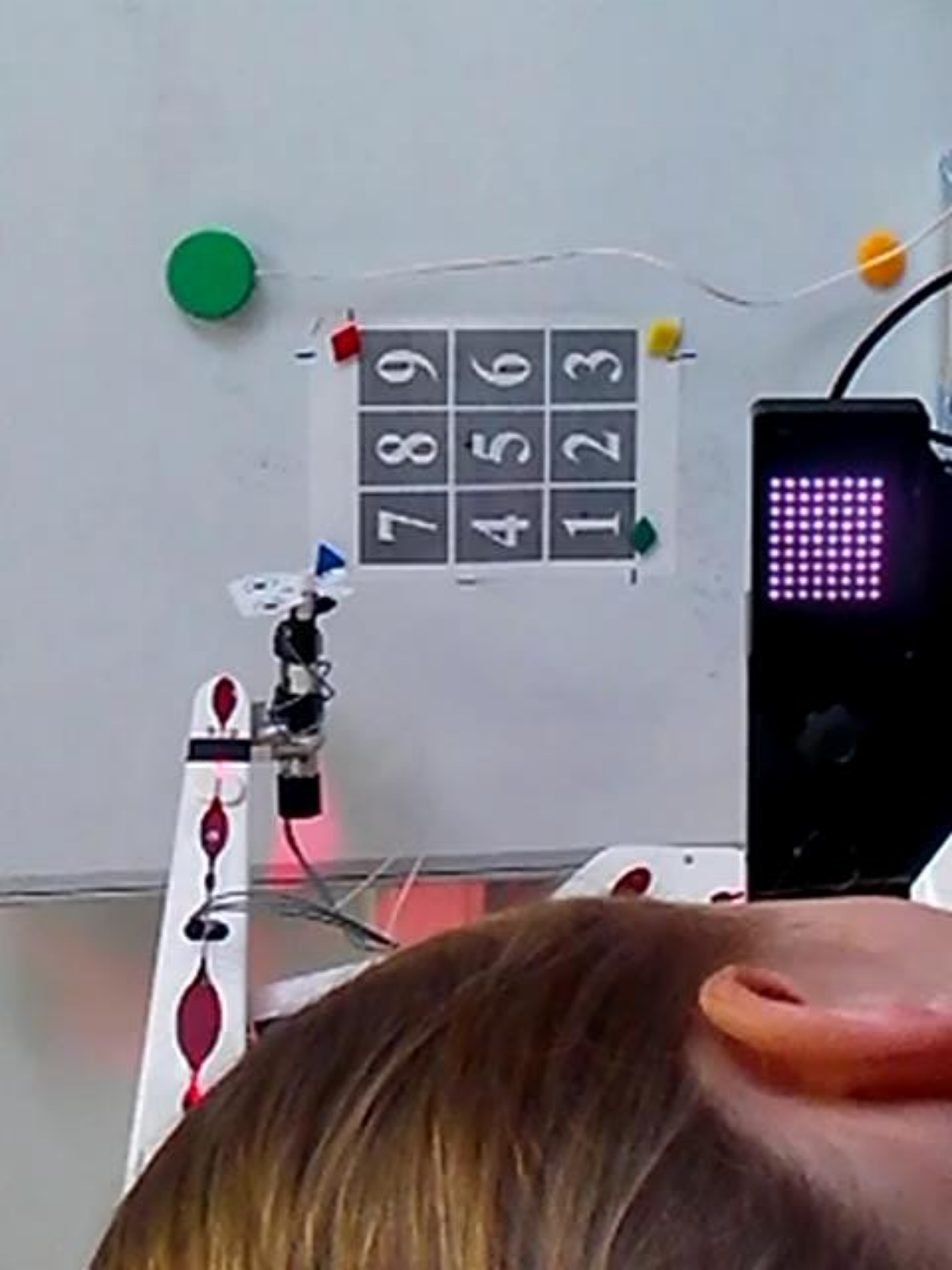
[1]Department of Neurocognitive Technologies, Kurchatov Complex of NBICS Technologies, National Research Centre "Kurchatov Institute," Moscow, Russia


РОССИЯ К


9 6 3
8 5 2
7 4 1

Комплексный характер задач:

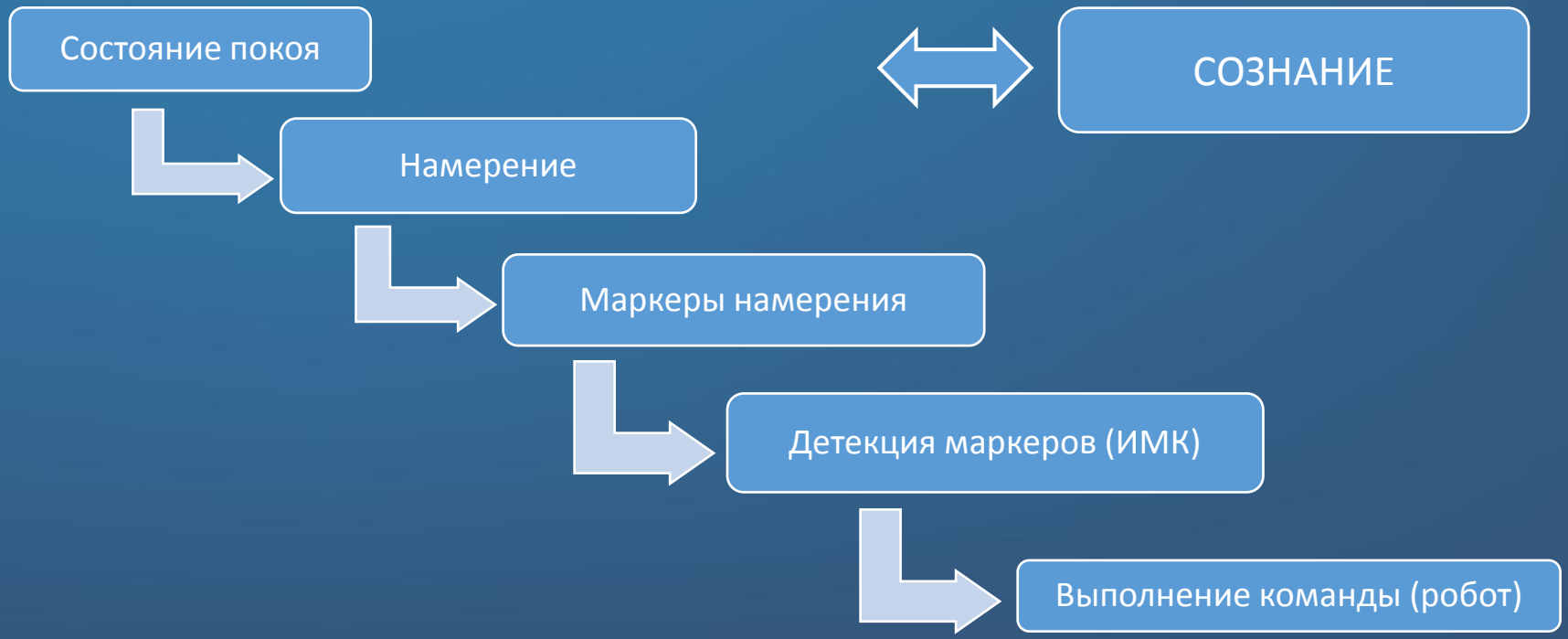
- разнообразие методик и оборудования

Пример: интерфейс глаз-мозг-компьютер для управления робототехникой

Комплексный характер задач:

- разнообразие ракурсов исследований и разработок

Пример: исследование порождения произвольного действия и разработка интерфейсов мозг-компьютер (ИМК)

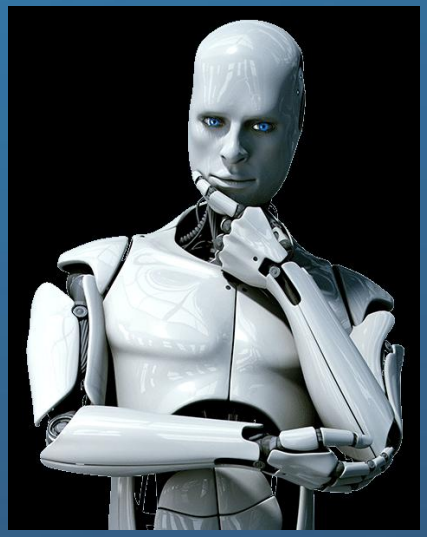


Комплексный характер задач:

- разнообразие ракурсов исследований и разработок

Пример: «инструментальное» и «коммуникативное» взаимодействие

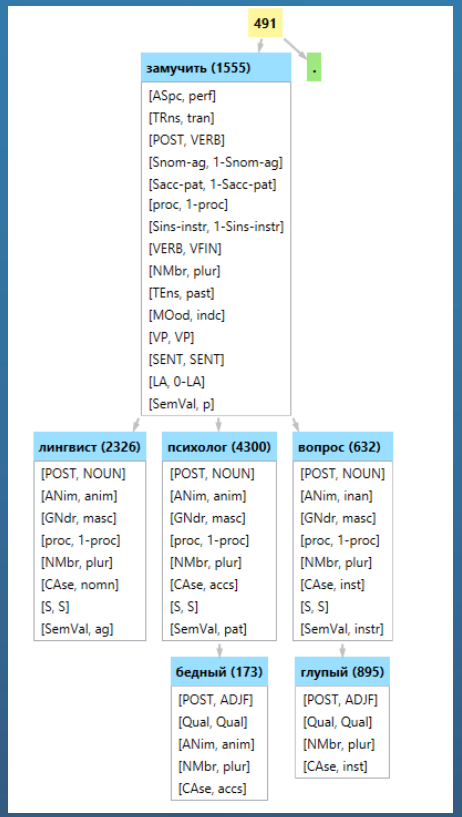
Манипулятор как «третья рука»



Антропоморфный робот как партнер

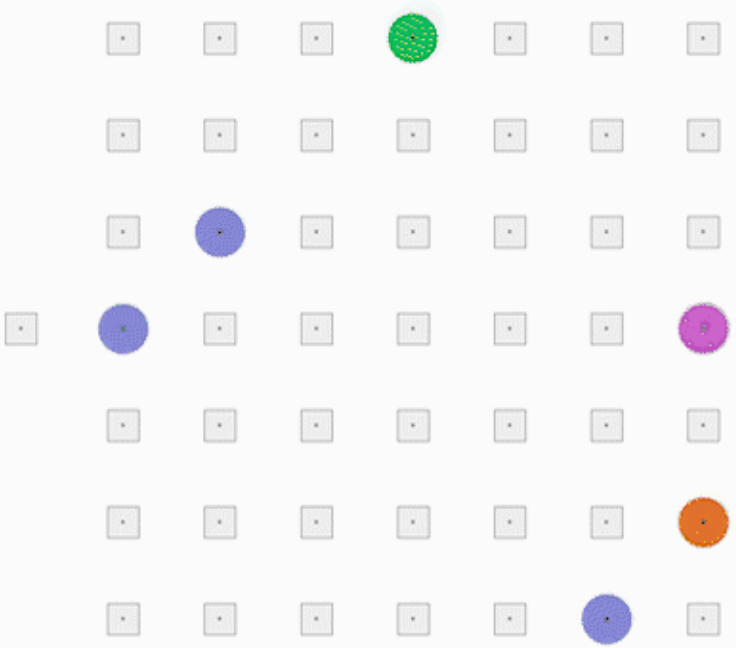
9. Основные научные результаты

Методы анализа текста и моделирования процессов коммуникации

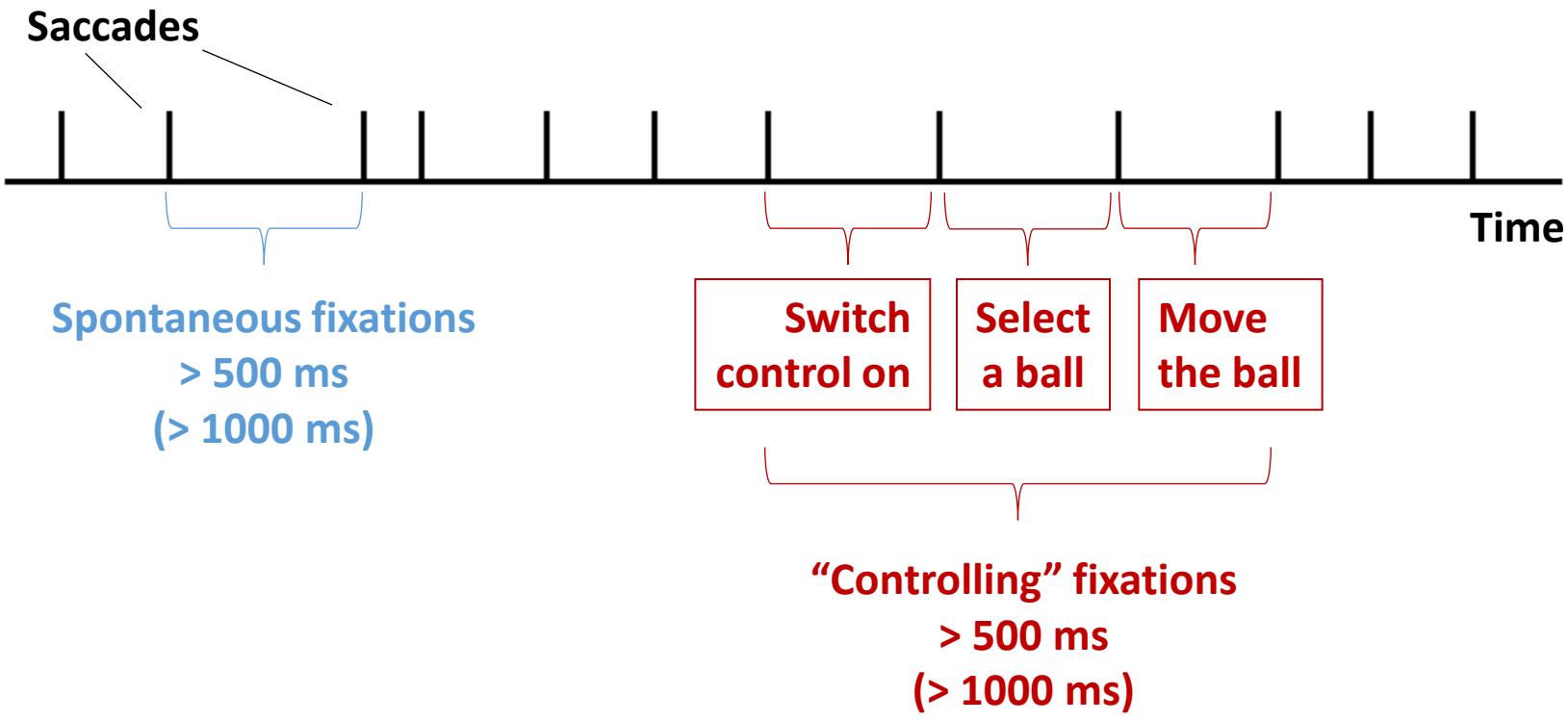


- Собрана **крупная база эмоциональных текстов:**
  - видеозаписи эмоциональных диалогов с разметкой речи, мимики и жестов
  - эмоциональные тексты и графические материалы из Интернета (Гособоронзаказ, контракт №2015/208)
- Создается **система автоматического анализа текста**, обеспечивающая:
  - извлечение из текста фактов и эмоций
  - управление коммуникацией мобильных роботов и компьютерных агентов

Our tool for finding the EEG/MEG markers of intention-related fixations: *EyeLines* game

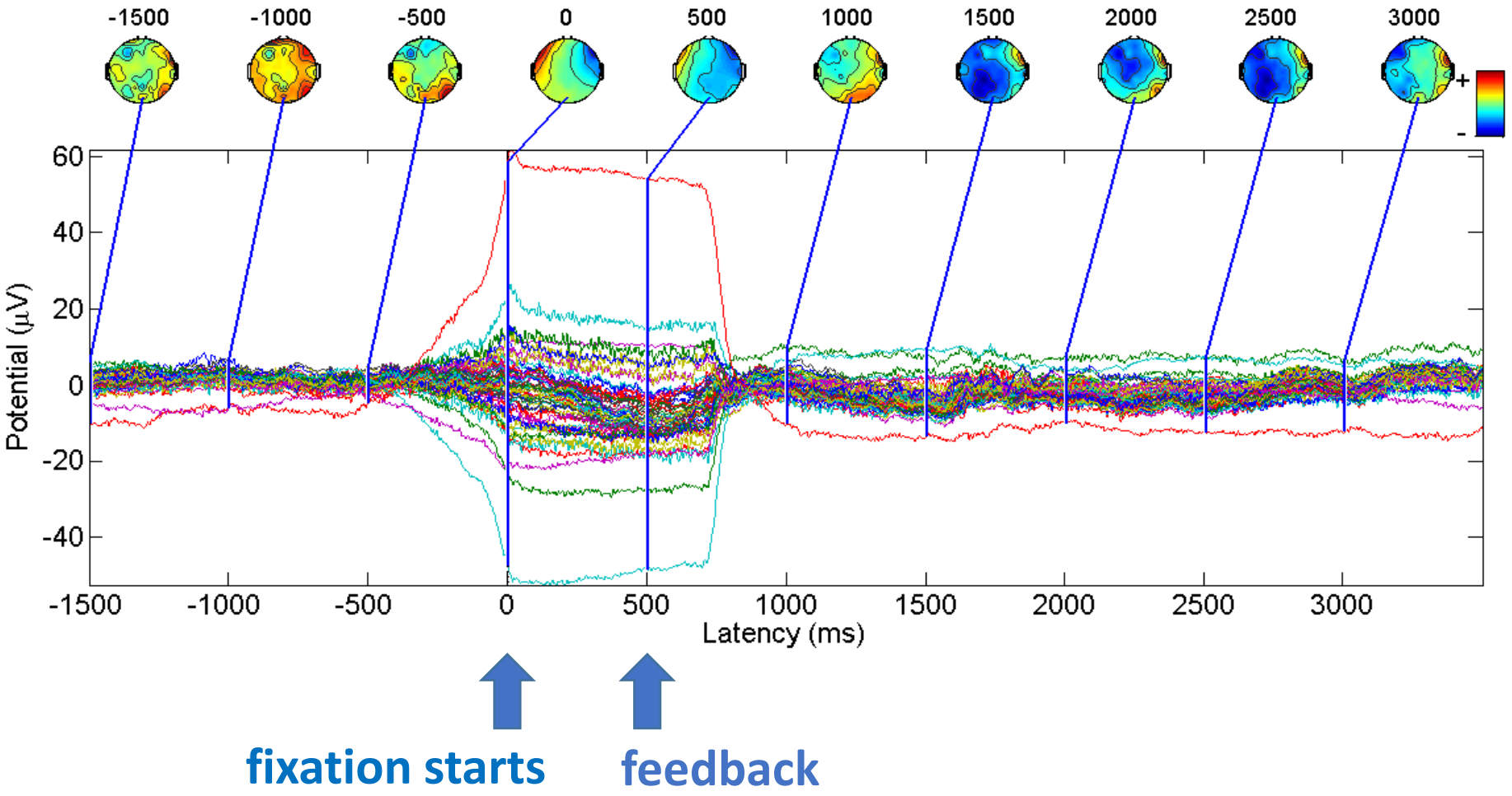


EEG during gaze fixations

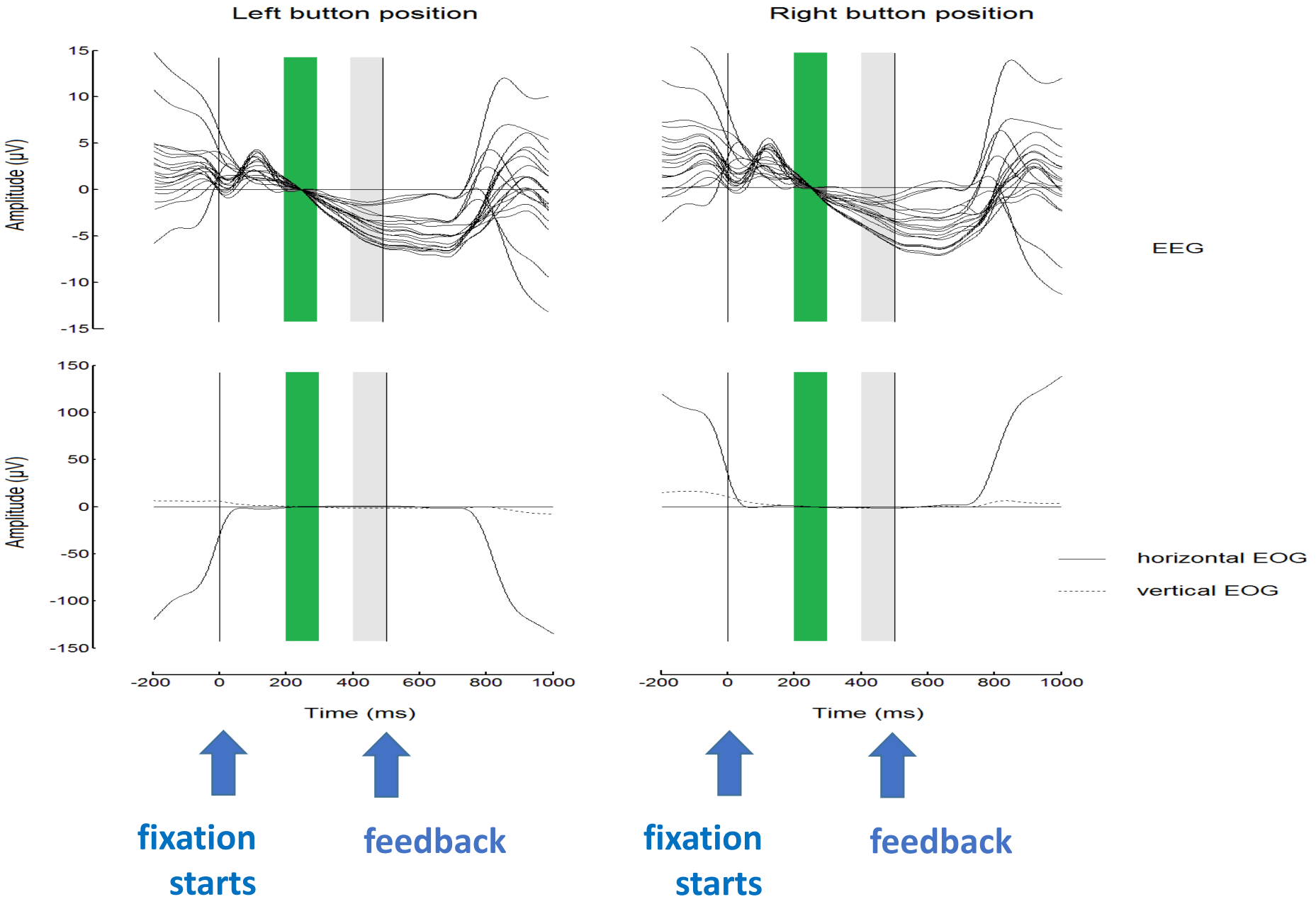


Sbj.	500 ms fixation threshold					1000 ms fixation threshold				
	No-control fixations	Control fixations				No-control fixations	Control fixations			
		All	Button	Ball	Free cell		All	Button	Ball	Free cell
1	114	444	150	148	146	9	369	124	123	122
2	208	364	120	128	116	15	271	101	96	74
3	144	408	138	139	131	13	325	109	108	108
4	200	549	184	184	181	24	446	150	148	148
5	162	435	147	148	140	4	338	113	113	112
6	124	527	176	180	171	5	428	145	142	141
7	123	442	151	153	138	7	358	122	121	115
8	194	517	171	175	171	9	378	125	127	126
Mean	**158.6**	**460.8**	**154.6**	**156.9**	**149.3**	**10.8**	**364.1**	**123.6**	**122.3**	**118.3**
Std	38.0	64.1	21.2	20.4	22.7	6.5	56.0	16.9	17.1	22.6

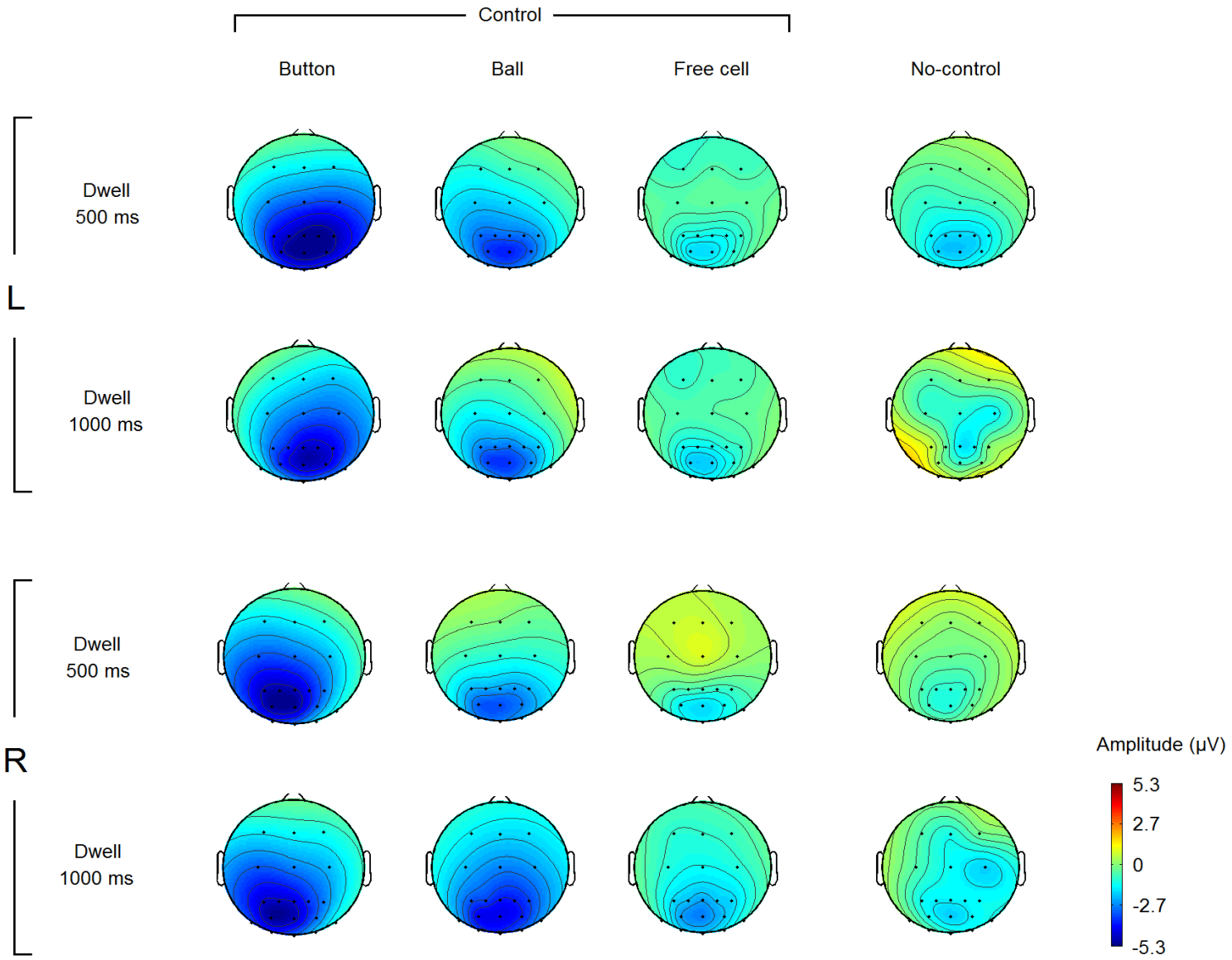
Methodical problems: contamination by EOG



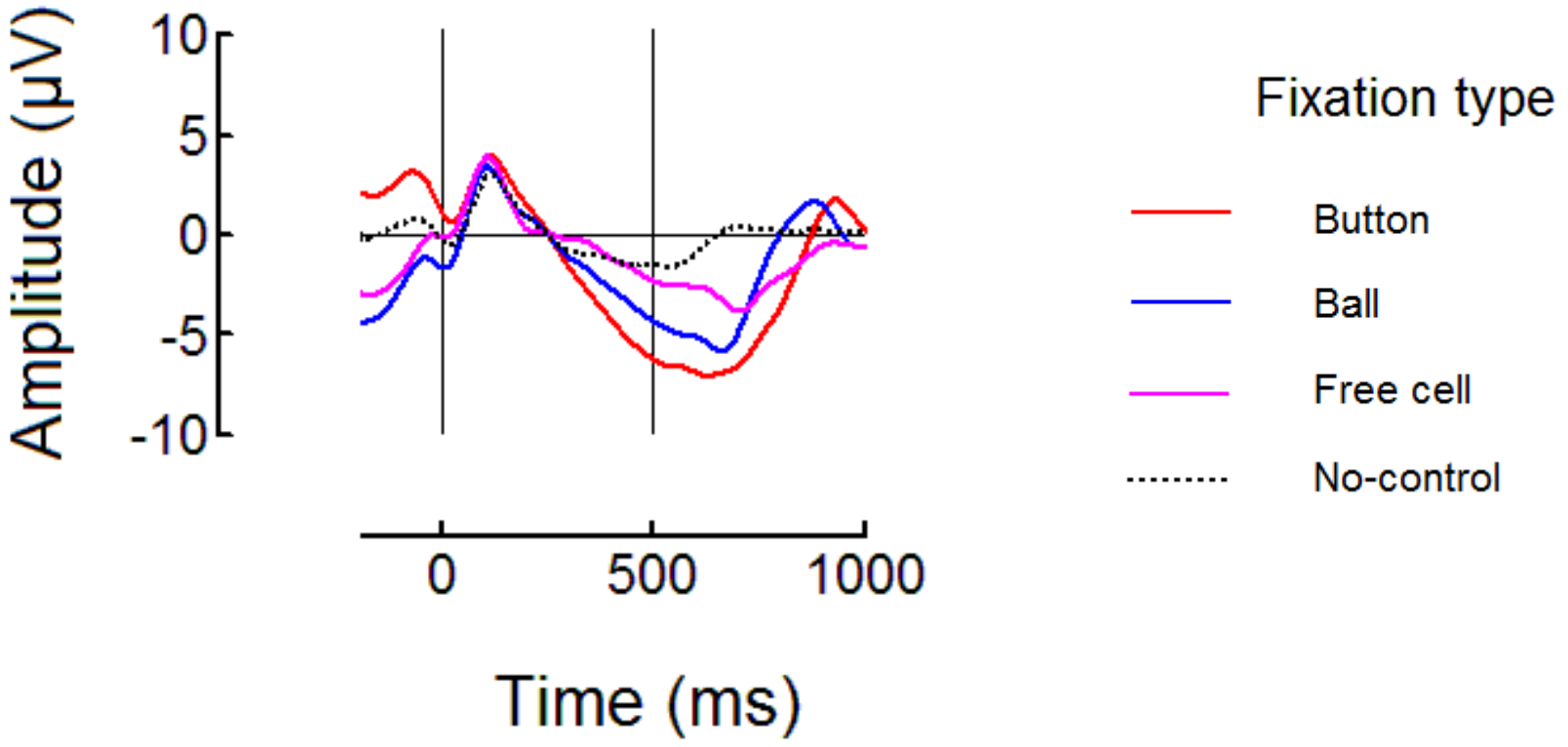
Solution: baseline +200..+300 ms



Amplitude maps, grand average (n=8)
400..500 ms after fixation onset

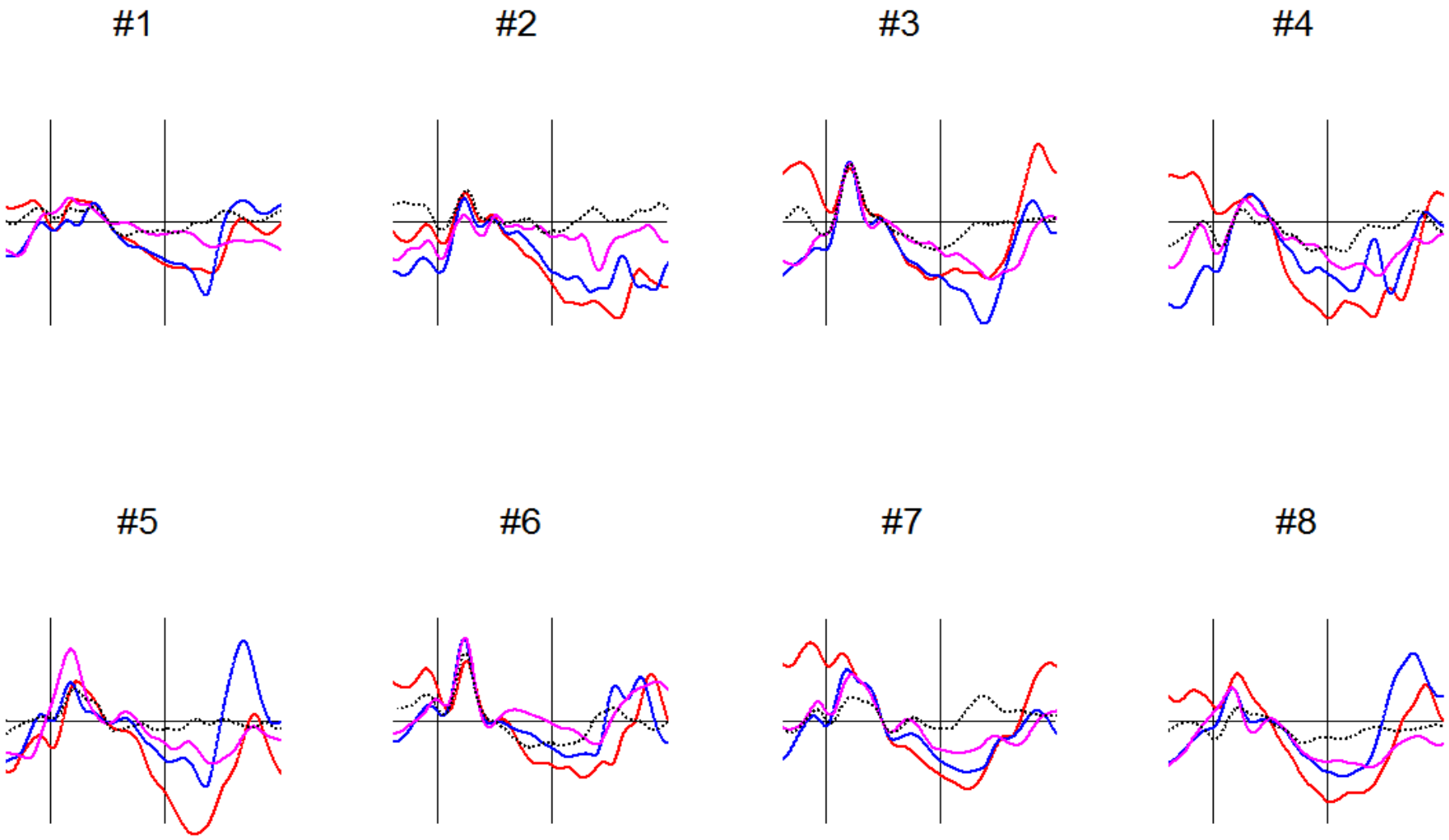


Fixation-related potentials, grand average
Pz (n = 8)



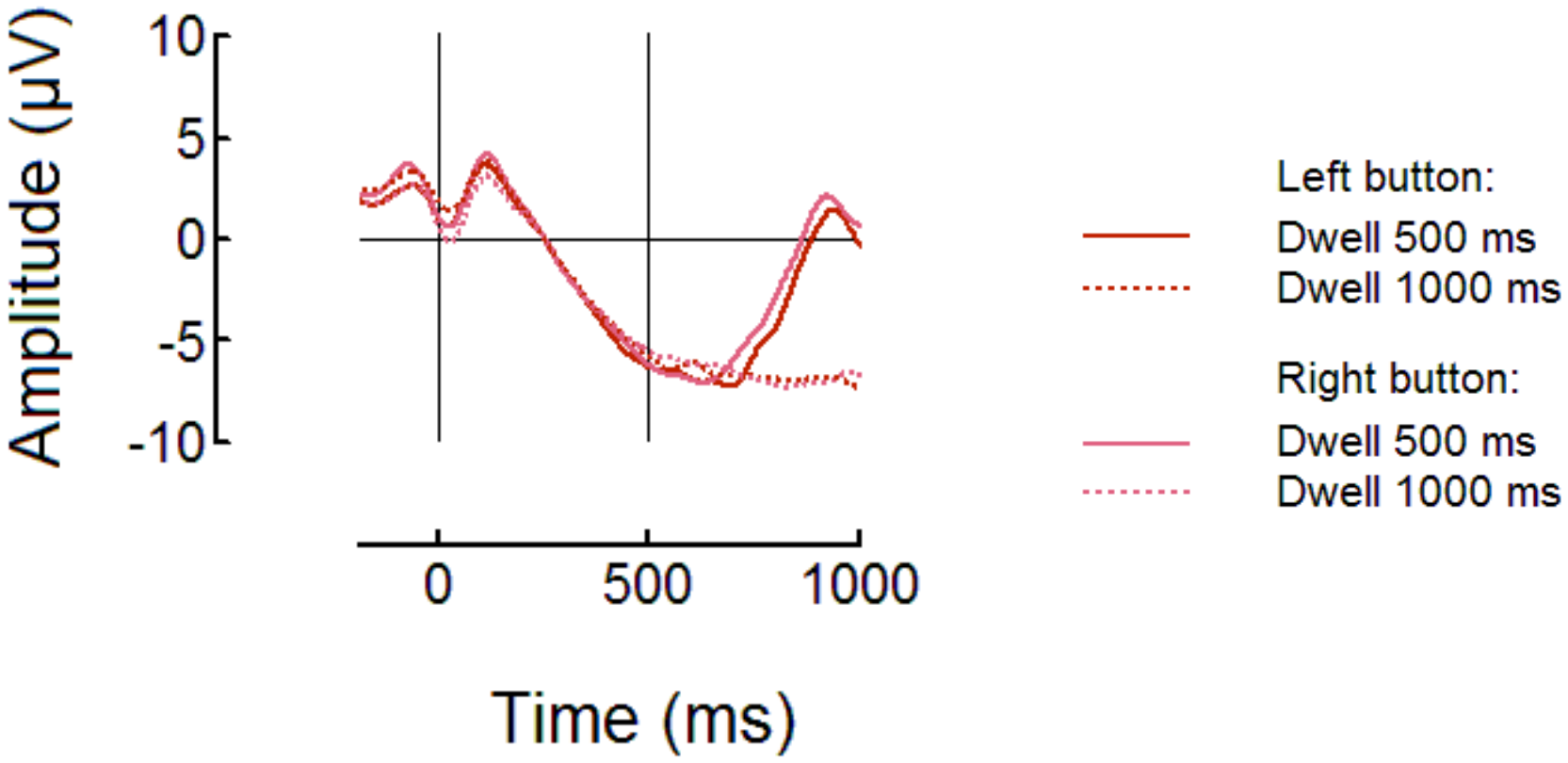
Individual fixation-related potentials

Pz



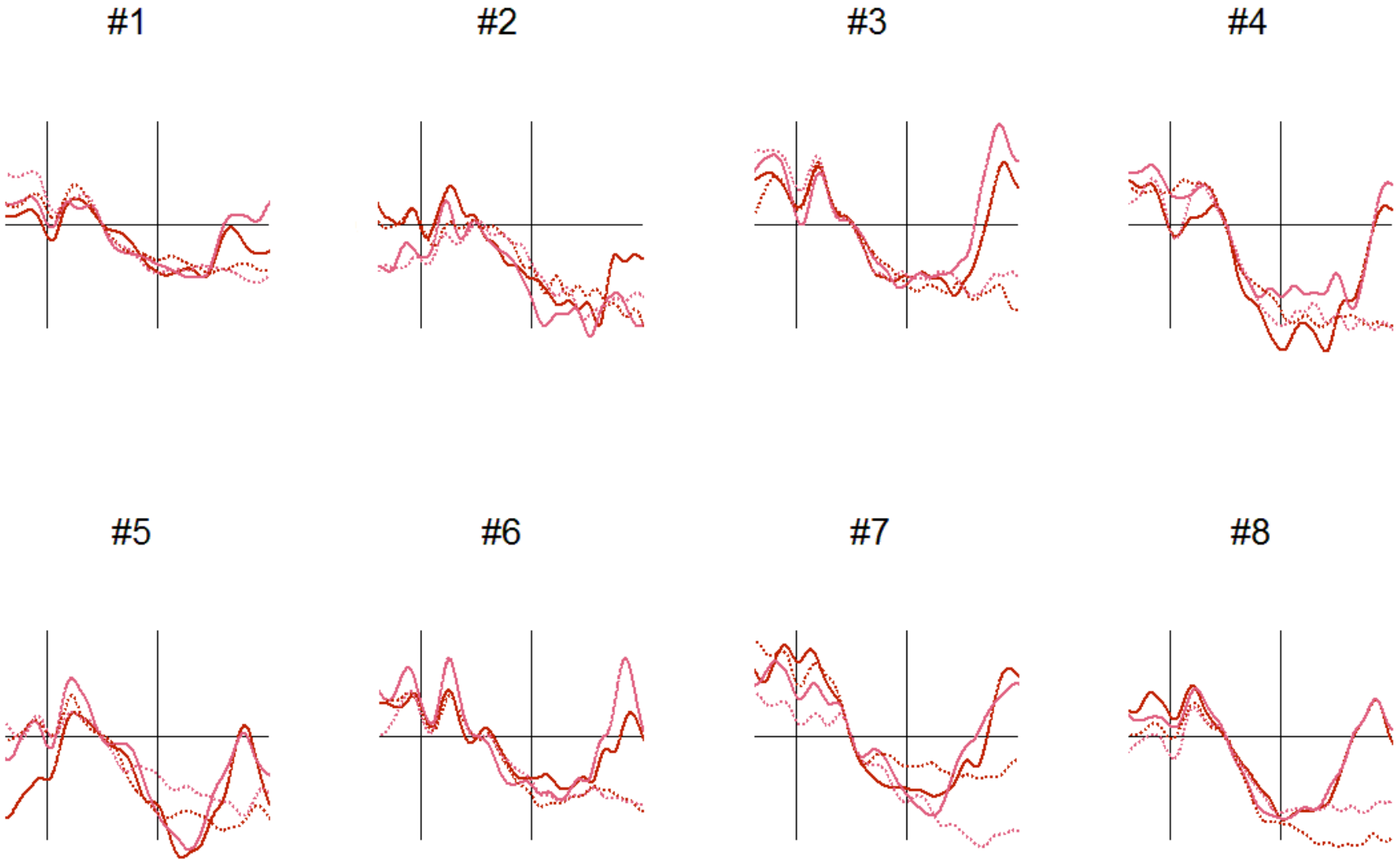
Fixation-related potentials, grand average

Pz (n = 8)

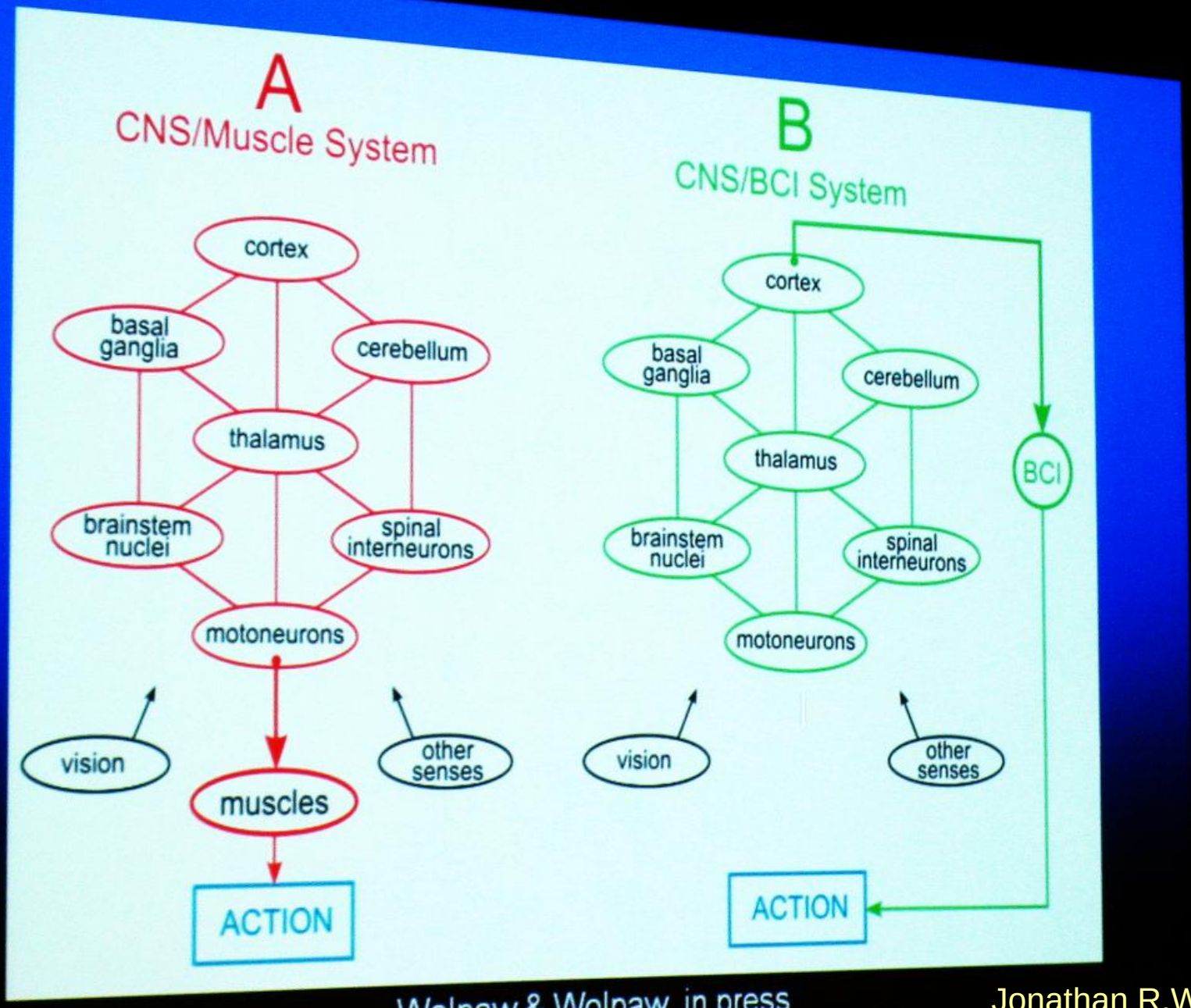


Individual fixation-related potentials

Pz




60
MINUTES



Jonathan R.Wolpaw
Invited lecture at 5th Int. BCI Conference, Graz, 24 Oct. 2011.

All high-performance non-invasive BCIs are gaze-dependent!

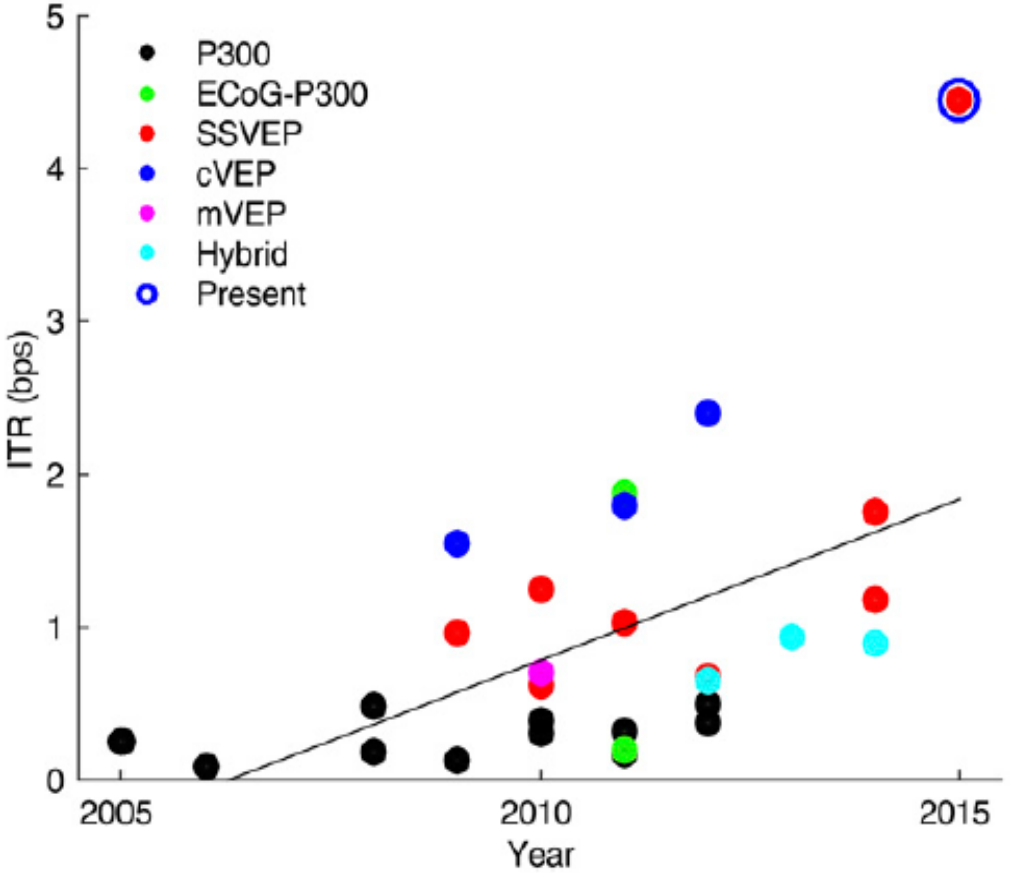
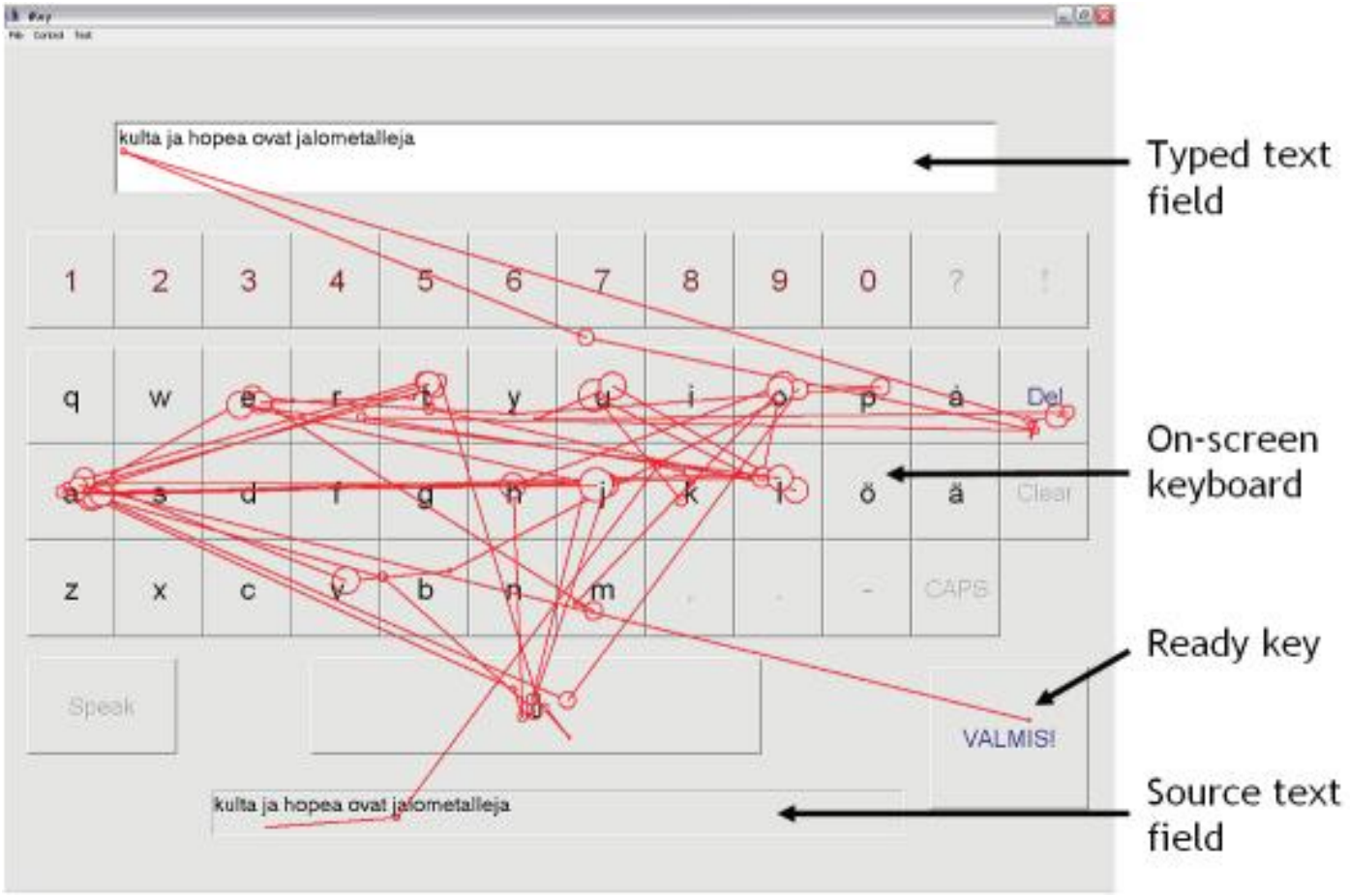


Fig. 6. Information transfer rates of current BCI spellers. The data points indicate BCI studies characterized by "online" and "speller" from Thomson Reuters Web of Science and the present study. To emphasize practicality, the studies without online spelling tasks were not included. The line shows a linear fit for all data points, indicating a significant increase of ITR during the past decade ($P < 0.01$, $r = 0.53$). "mVEP" indicates motion VEP and "hybrid" indicates systems using multiple EEG signals (e.g., SSVEP and P300).

Chen et al., High-speed spelling with a noninvasive brain–computer interface, PNAS, 2015

Typing with gaze fixations



From Päivi Majaranta, Text Entry by Eye Gaze, 2009

The Use of Eye Movements in Human-Computer Interaction Techniques: What You Look At is What You Get

ROBERT J. K. JACOB
Naval Research Laboratory

In seeking hitherto-unused methods by which users and computers can communicate, we investigate the usefulness of eye movements as a fast and convenient auxiliary user-to-computer communication mode. The barrier to exploiting this medium has not been eye-tracking technology but the study of interaction techniques that incorporate eye movements into the user-computer dialogue in a natural and unobtrusive way. [...]

ACM Transactions on Information Systems, Vol. 9, No 3, April 1991, Pages 152–169

The Midas Touch problem (Jacob, 1990, 1991)

- King Midas turned into gold everything he touched.

- An “eye – computer” interface execute commands each time the gaze touches a screen button –

  because eye movements are a very important part of the vision machinery!

  Tricks used to overcome the problem makes the interface use tiresome.

Features for the BCI classifier

The classifier should detect intentions in *single trials!*

- 13 EEG channels
- 200..500 ms

Raw amplitudes

- 200..250 ms, 220..270 ms, …, 440..490 ms

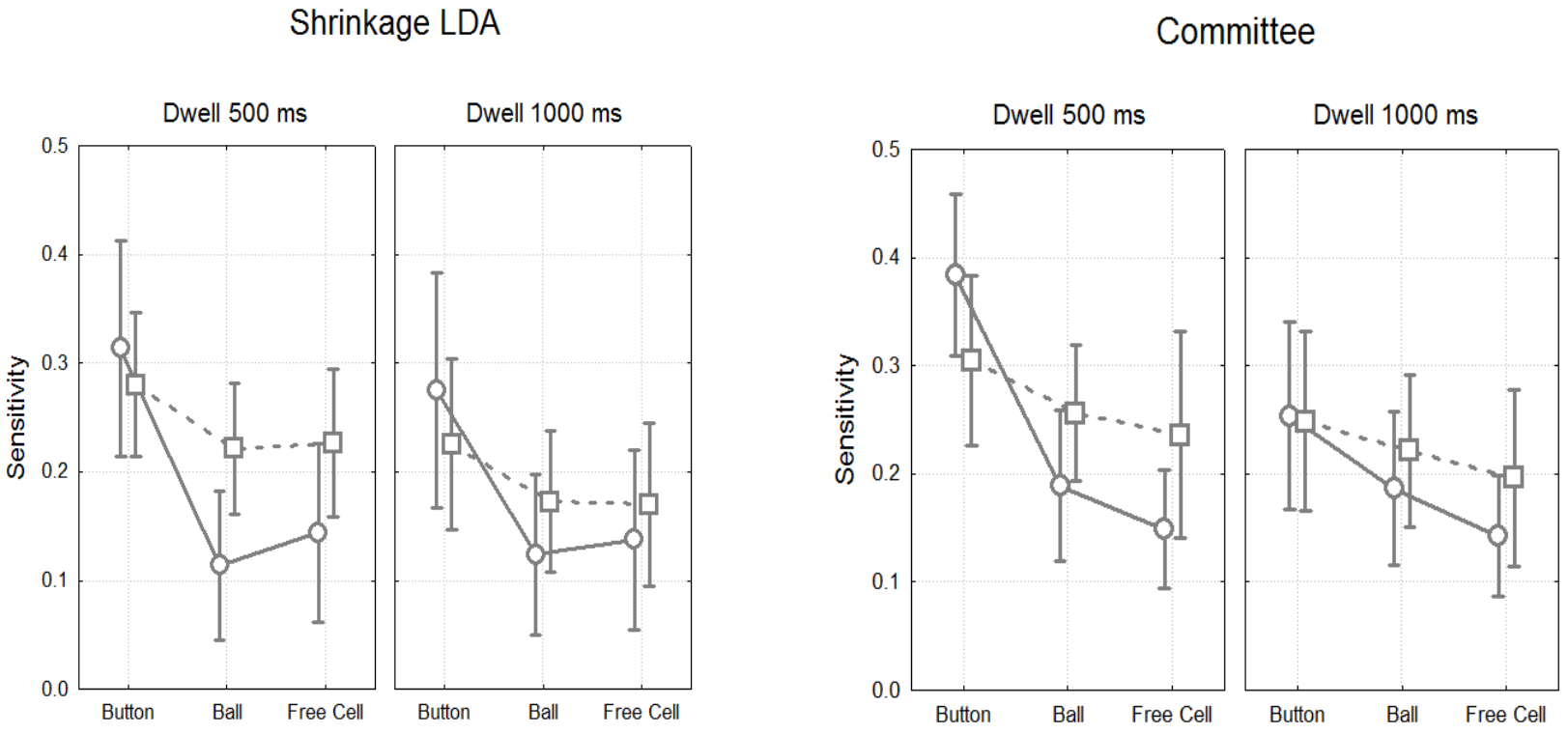
Wavelets

- Morlet, ~ 5..30 Hz
- 30% with highest R^2
- 80 PCA components
- Normalization (pre- & post-PCA)

- 5-fold cross-validation
- Validation subsets for feature selection and estimation of normalization parameters

BCI classifier performance (raw amplitude features)

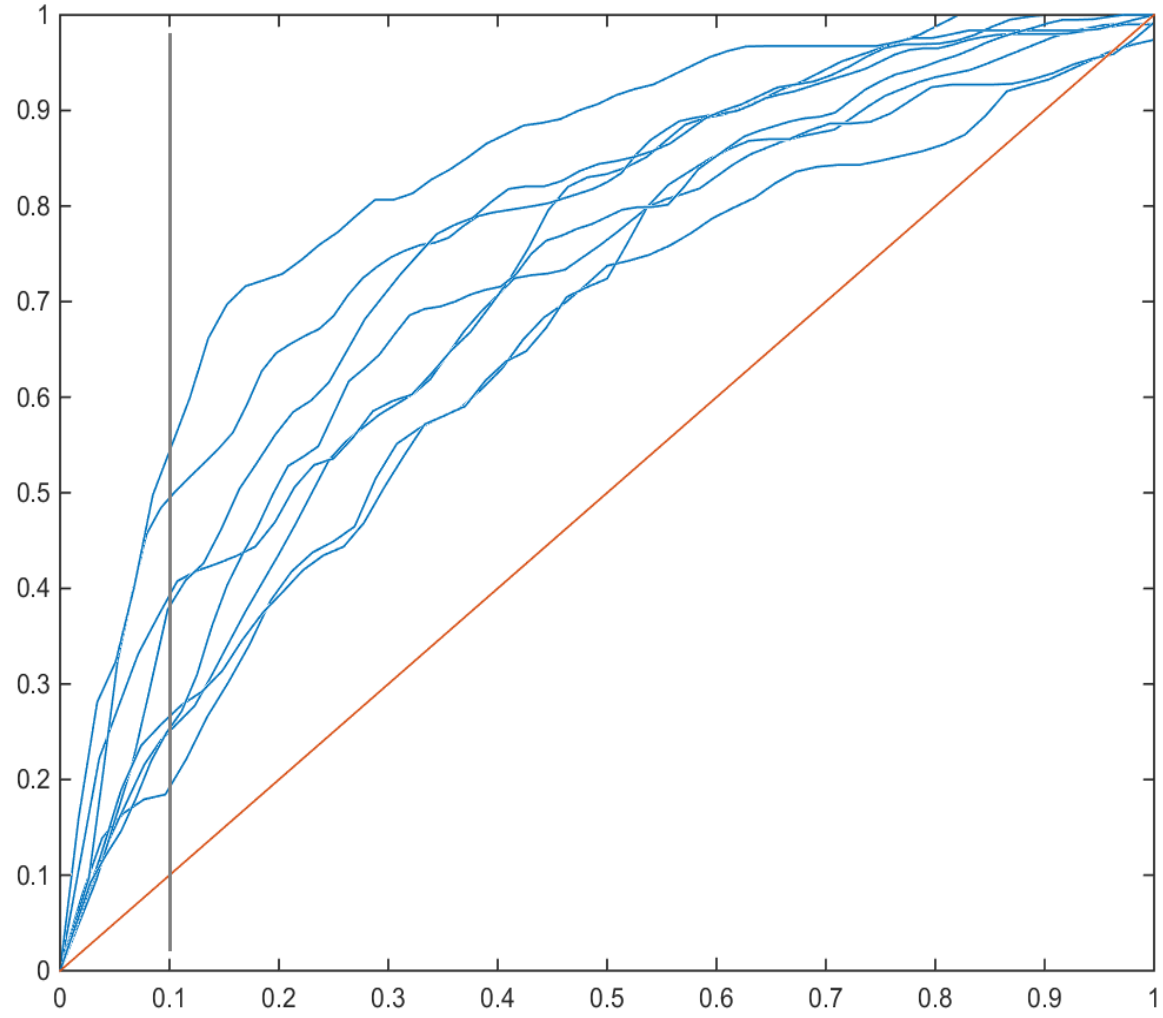
Specificity (false positive rate, FPR) ~ 0.1



FPR = 0.1 corresponds to 1 false response of the interface per 2-3 min (500 ms fixations are rare!)

BCI classifier performance (best results*)

True positive rate (correctly detected control)



False positive rate

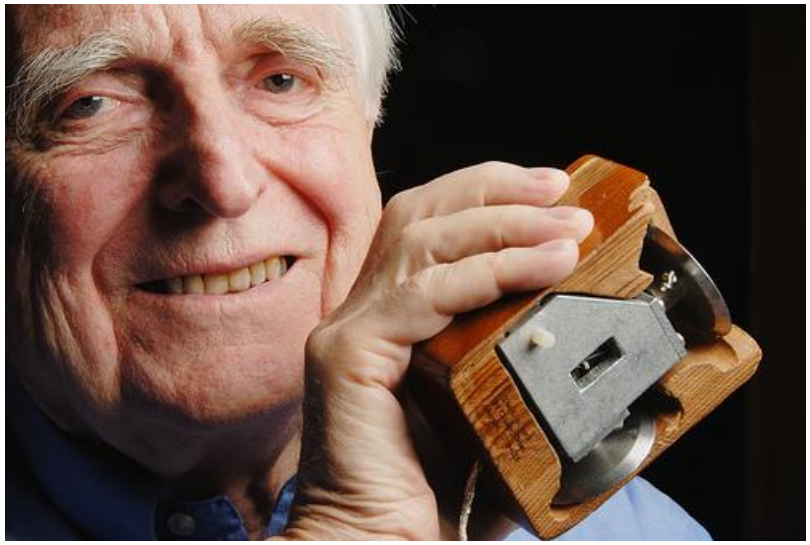
(*) Button

(*) 500 ms threshold

(*) Amplitude + wavelet features

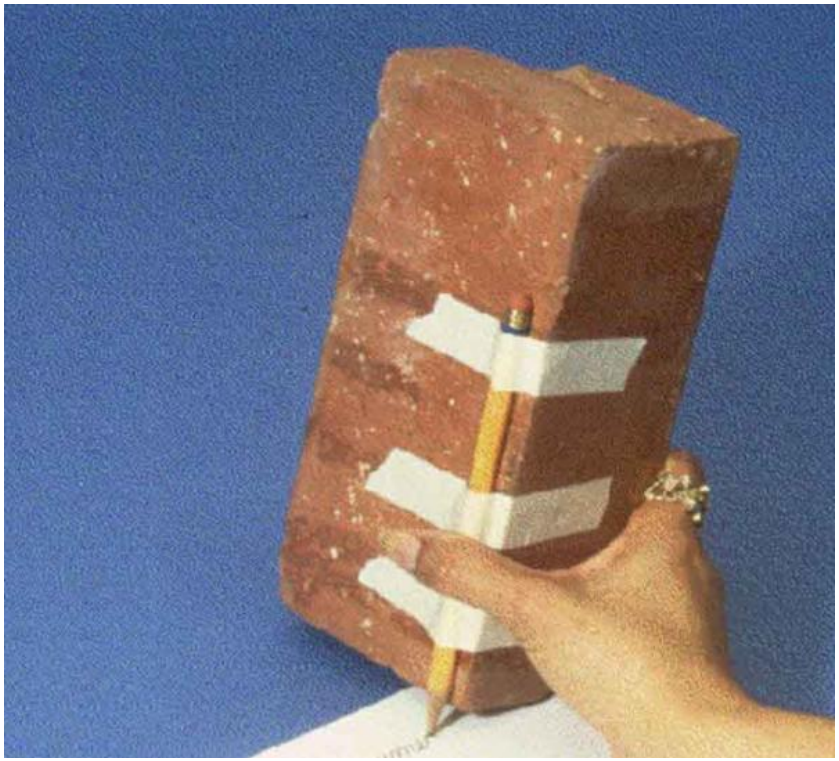
(*) Committee of greedy classifiers

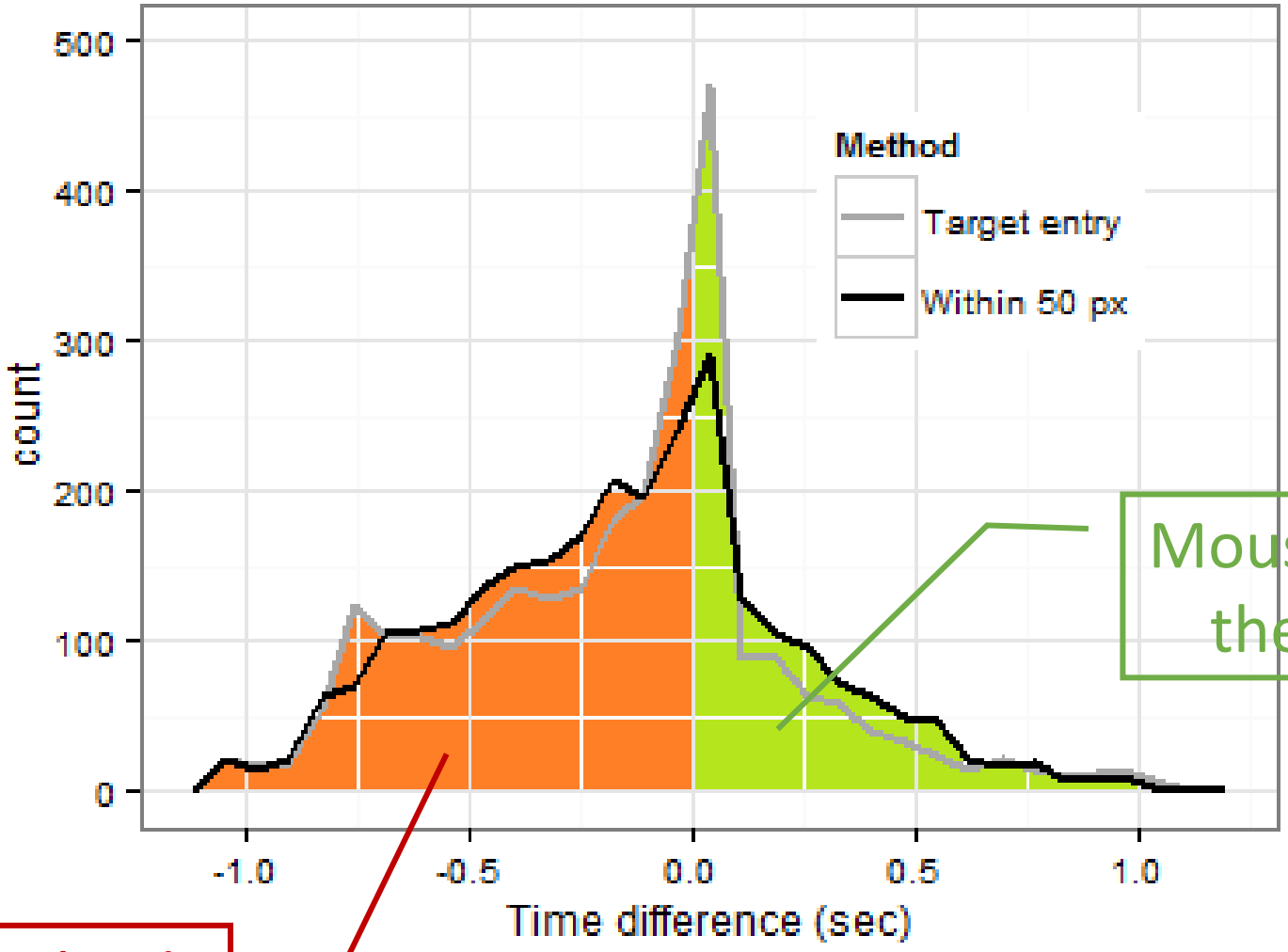
Douglas Engelbart
(1925 –2013)



- Mouse: X, Y, click
- Hypertext
- Elements of GUI
- …

Engelbart's pencil and brick experiment (*Augmenting Human Intellect: A Conceptual Framework* - 1962)





Liebling & Dumais, Gaze and Mouse Coordination in Everyday Work, ACM UbiComp 2014

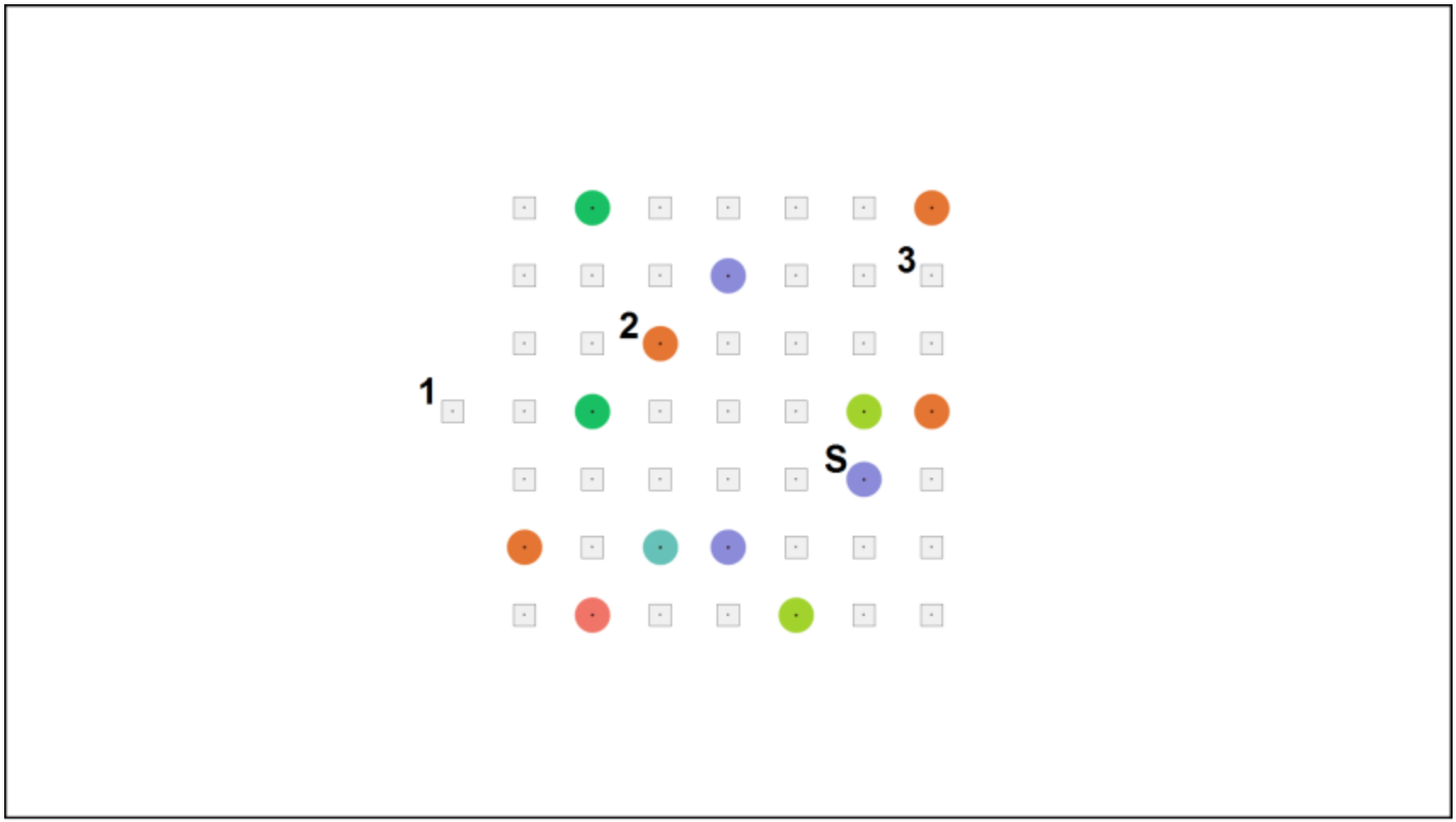
"Midas Touch" Problem

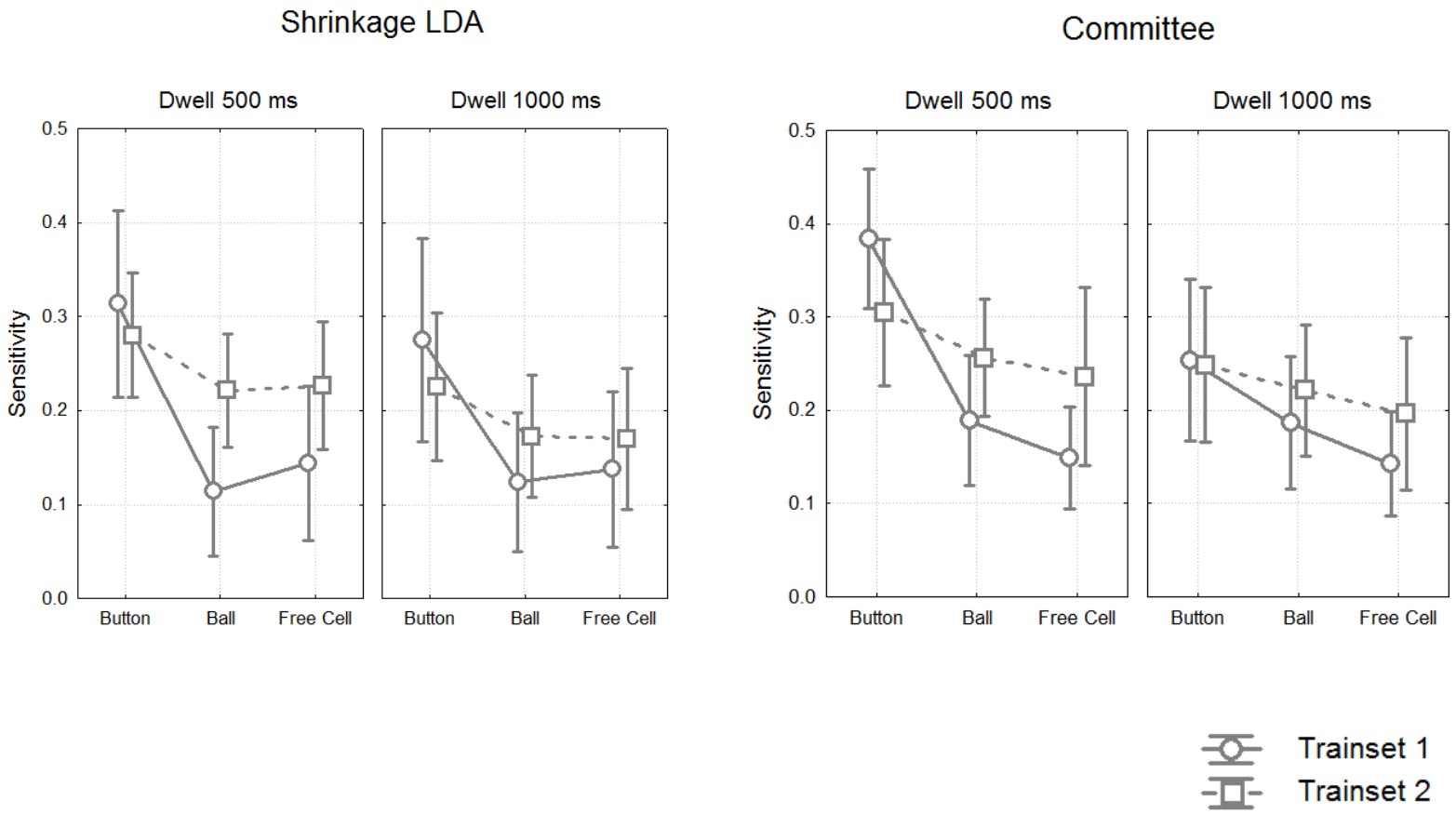
The most naive approach to using eye position as an input might be to use it as a direct substitute for a mouse: changes in the user's line of gaze would cause the mouse cursor to move. This is an unworkable (and annoying) approach, because people are not accustomed to operating devices just by moving their eyes. They expect to be able to look at an item without having the look "mean" something. Normal visual perception requires that the eyes move about, scanning the scene before them. It is not desirable for each such move to initiate a computer command.

At first, it is empowering to be able simply to look at what you want and have it happen, rather than having to look at it (as you would anyway) and then point and click it with the mouse or otherwise issue a command. Before long, though, it becomes like the Midas Touch. Everywhere you look, another command is activated; you cannot look anywhere without issuing a command. The challenge in building a useful eye tracker interface is to avoid this Midas Touch problem. [...]

ROBERT J. K. JACOB

ACM Transactions on Information Systems, Vol. 9, No 3, April 1991, Pages 152–169


1
2
3
S
Control fixations
S
Spontaneous fixation (no-control)
1
Button
2
Ball
3
Free cell


Shrinkage LDA
Committee
Dwell 500 ms
Dwell 1000 ms
Sensitivity
0.0
0.1
0.2
0.3
0.4
0.5
Button
Ball
Free Cell
Trainset 1
Trainset 2

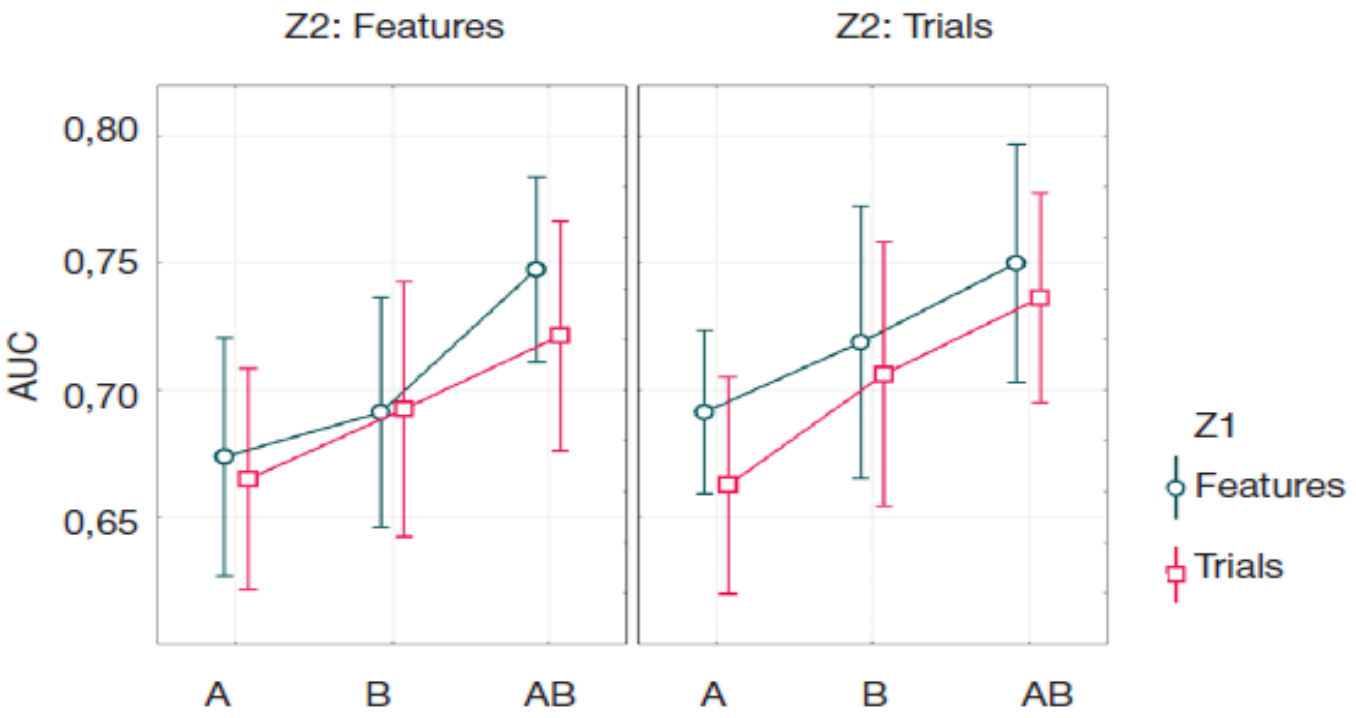


Fig. 1. Dependence of classification accuracy (AUC) for gaze fixations (control and non-control) on the method used for feature extraction from EEG recorded during gaze fixation

Legend: A — amplitude features only, B — wavelet features only, AB — combined (amplitude-wavelet) set of features; Z1 — normalization type before PCA; Z2 — normalization type after PCA; features: normalization of separate features; trials — normalization of features within a single trial. Vertical lines represent 95 % confidence intervals.

Not for sequential operation, but can be used to start a sequence (which will be executed with other approaches)