

Zrakové vyhledávání

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Psychologický ústav AV ČR

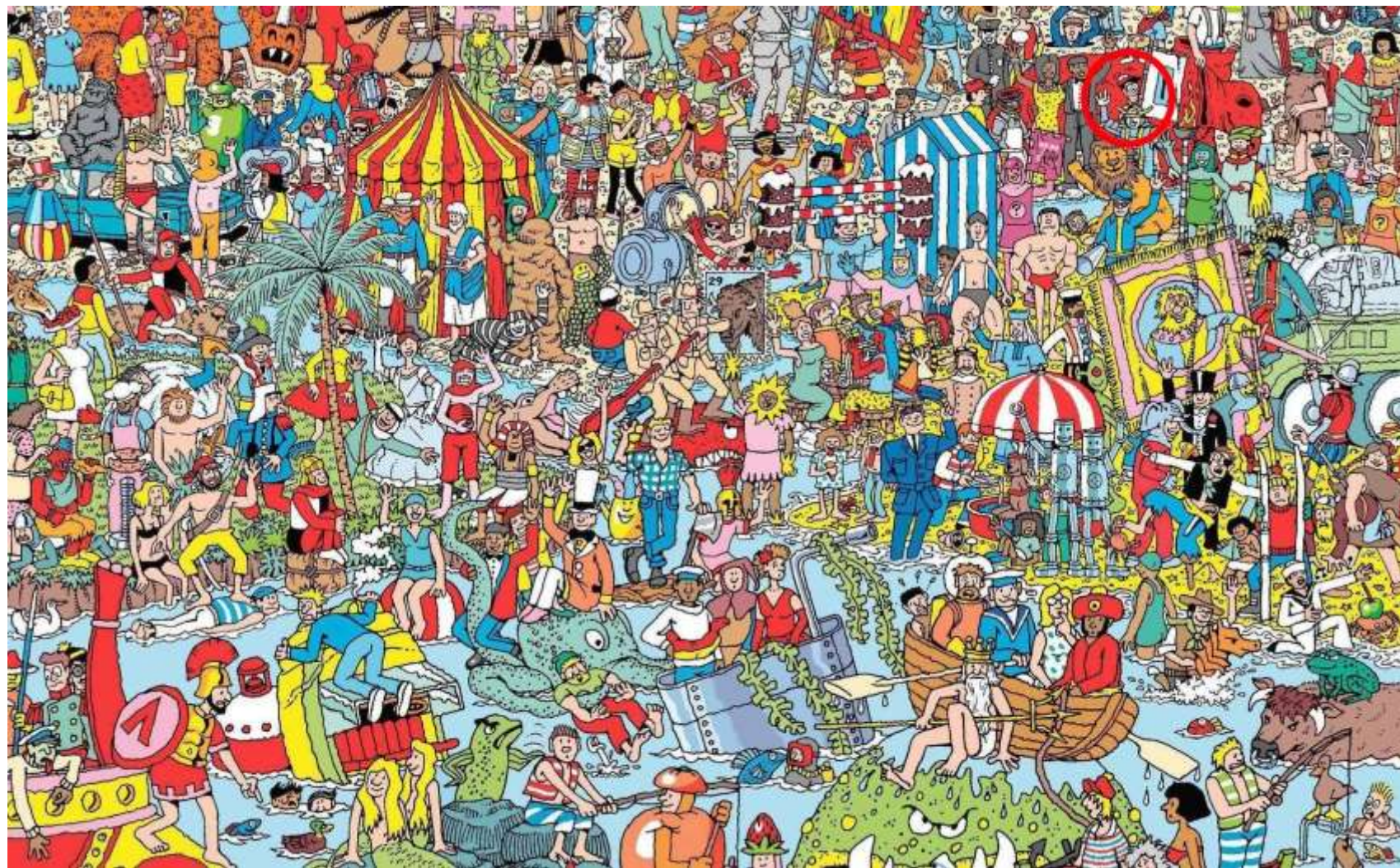


Co je zrakové vyhledávání?



Kde je Waldo?





V laboratoři

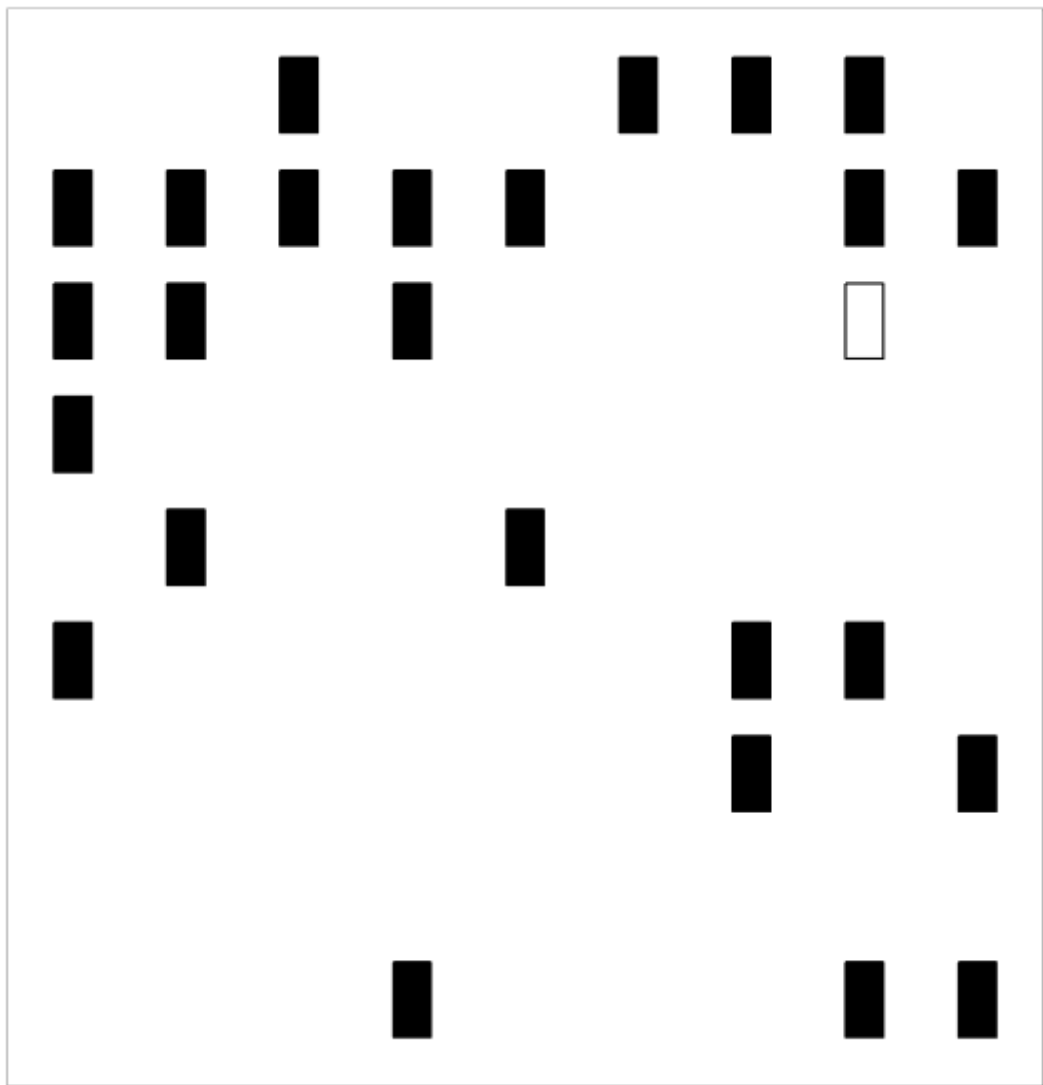
Úkolem je najít bílý svislý obdélník



mezi černými svislými obdélníky







Těžší úloha (ale stále lehká)

Úkolem je najít bílý svislý obdélník



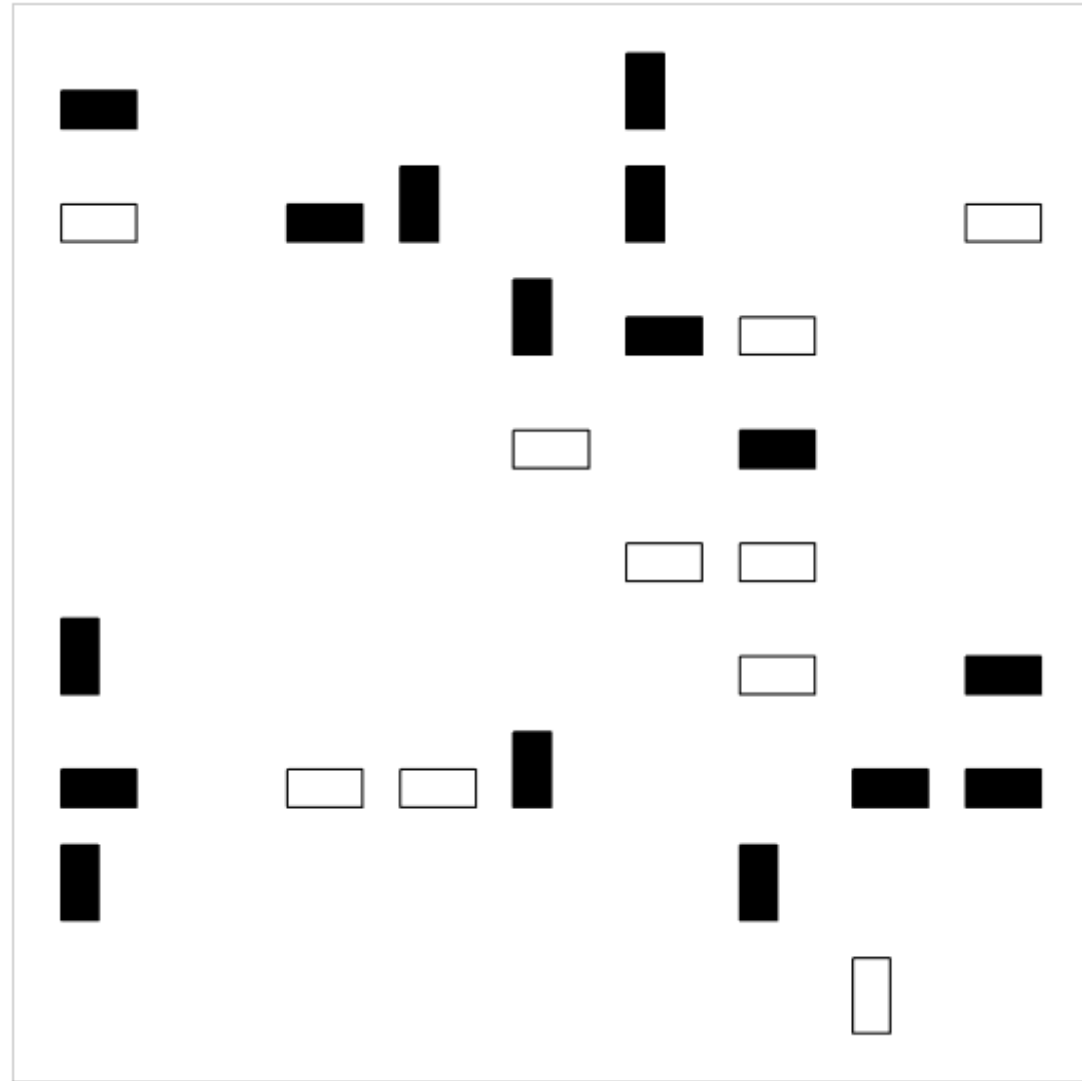
mezi černými svislými



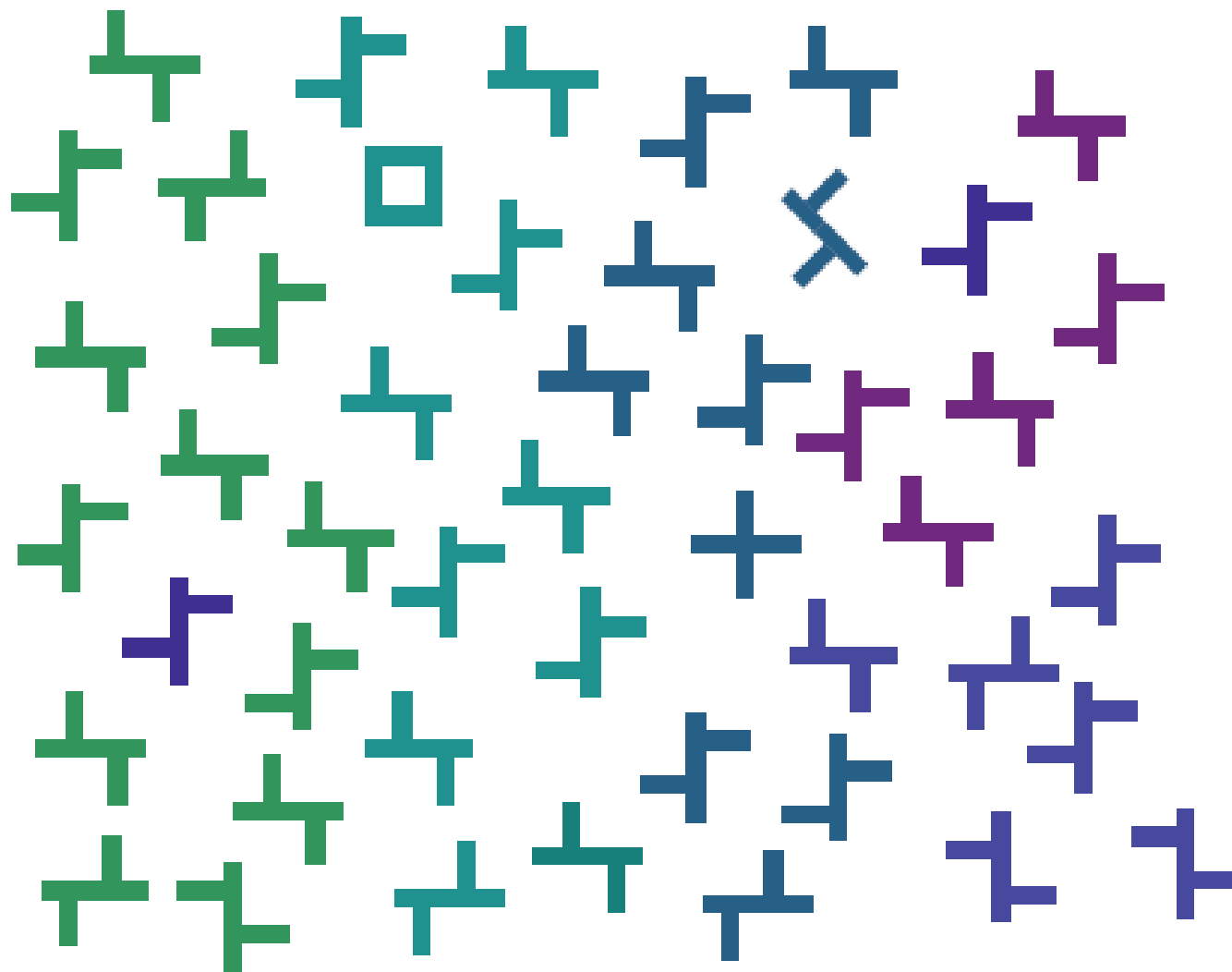
a bílými vodorovnými obdélníky



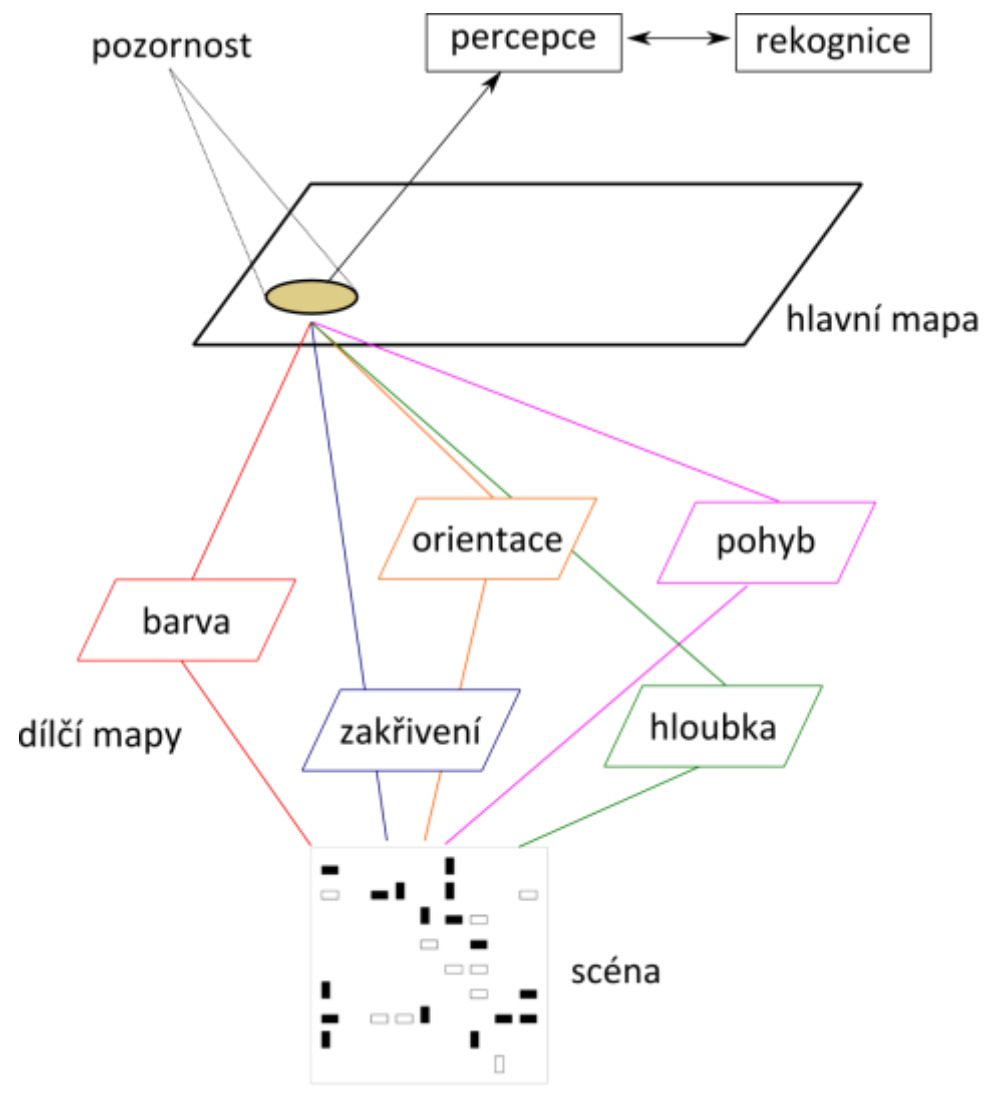
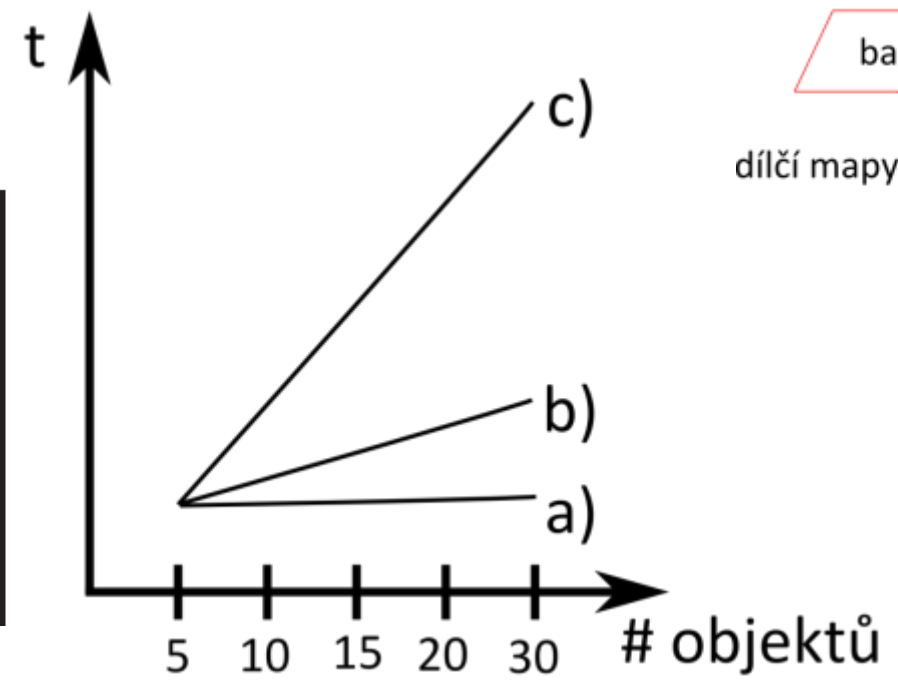
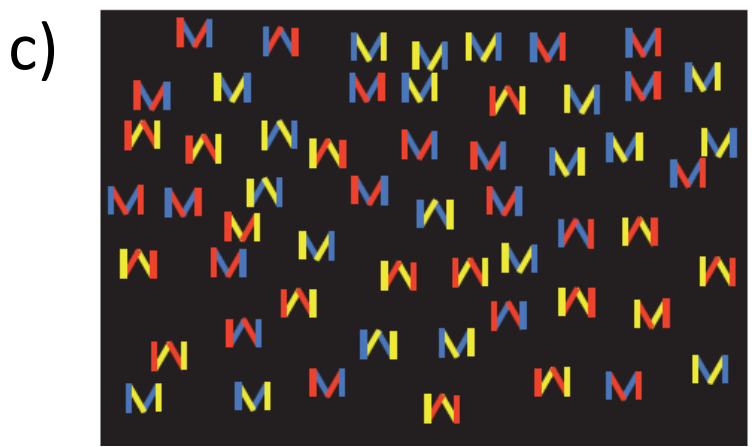
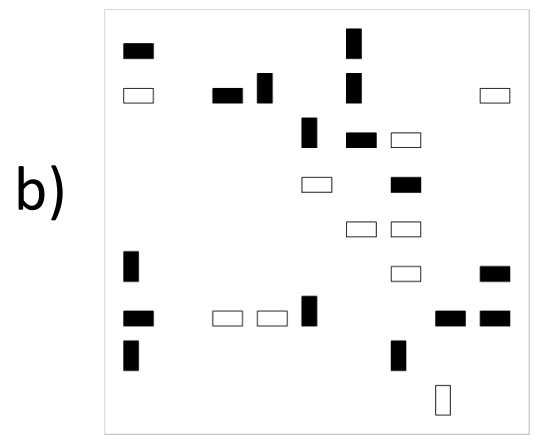
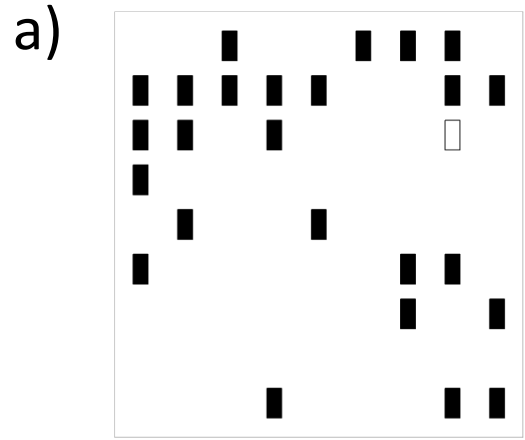




Pop out



Jde o jiné mechanismy

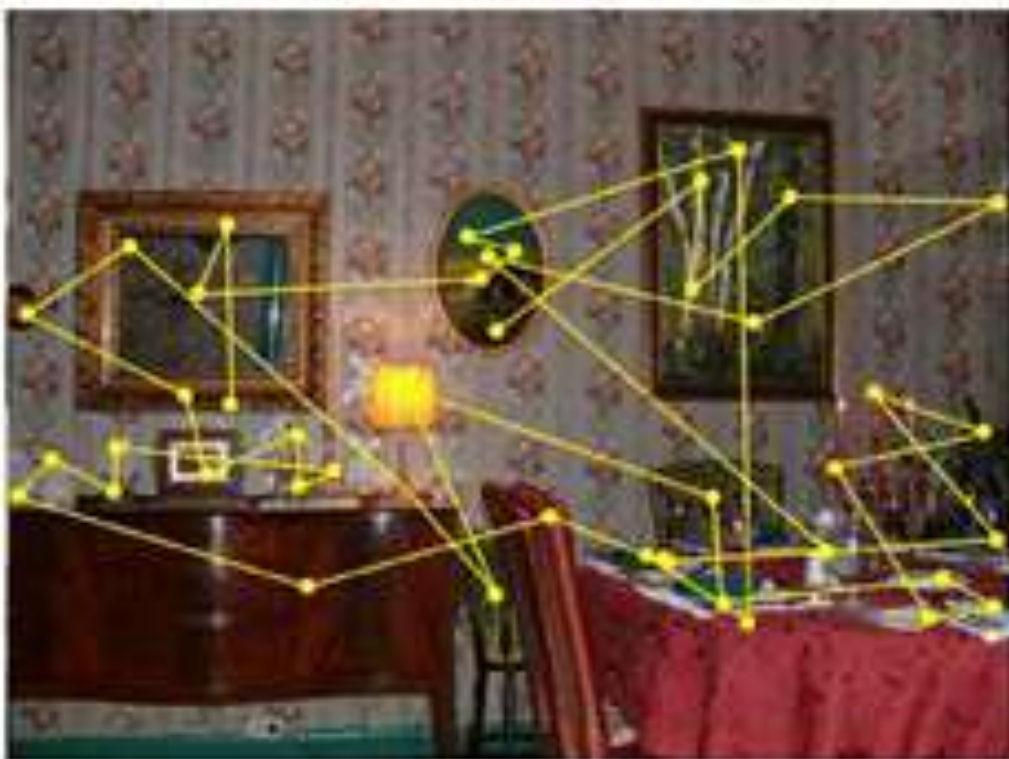


Co reálné úlohy?



Modelování skrze oční pohyby

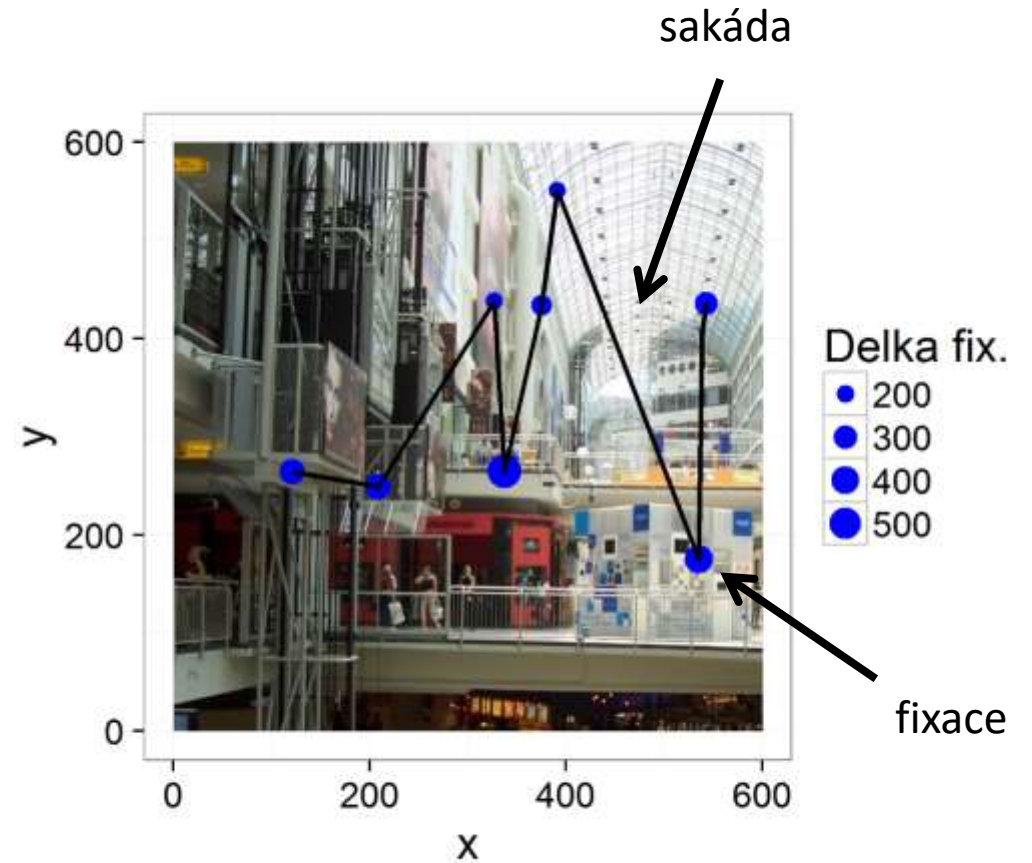
Memorization Task



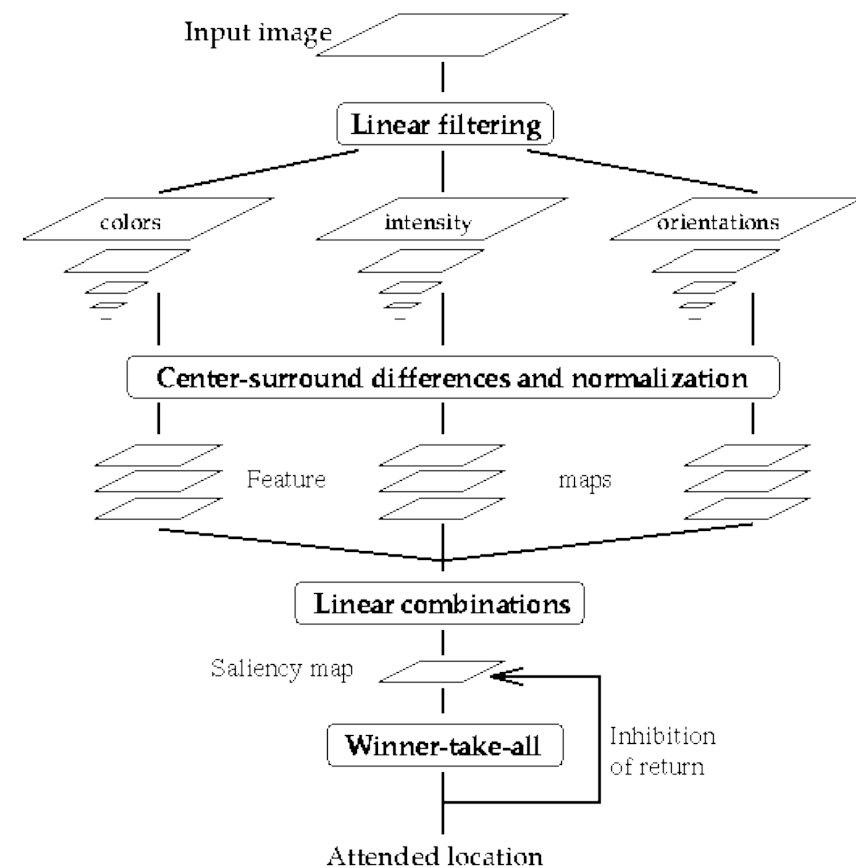
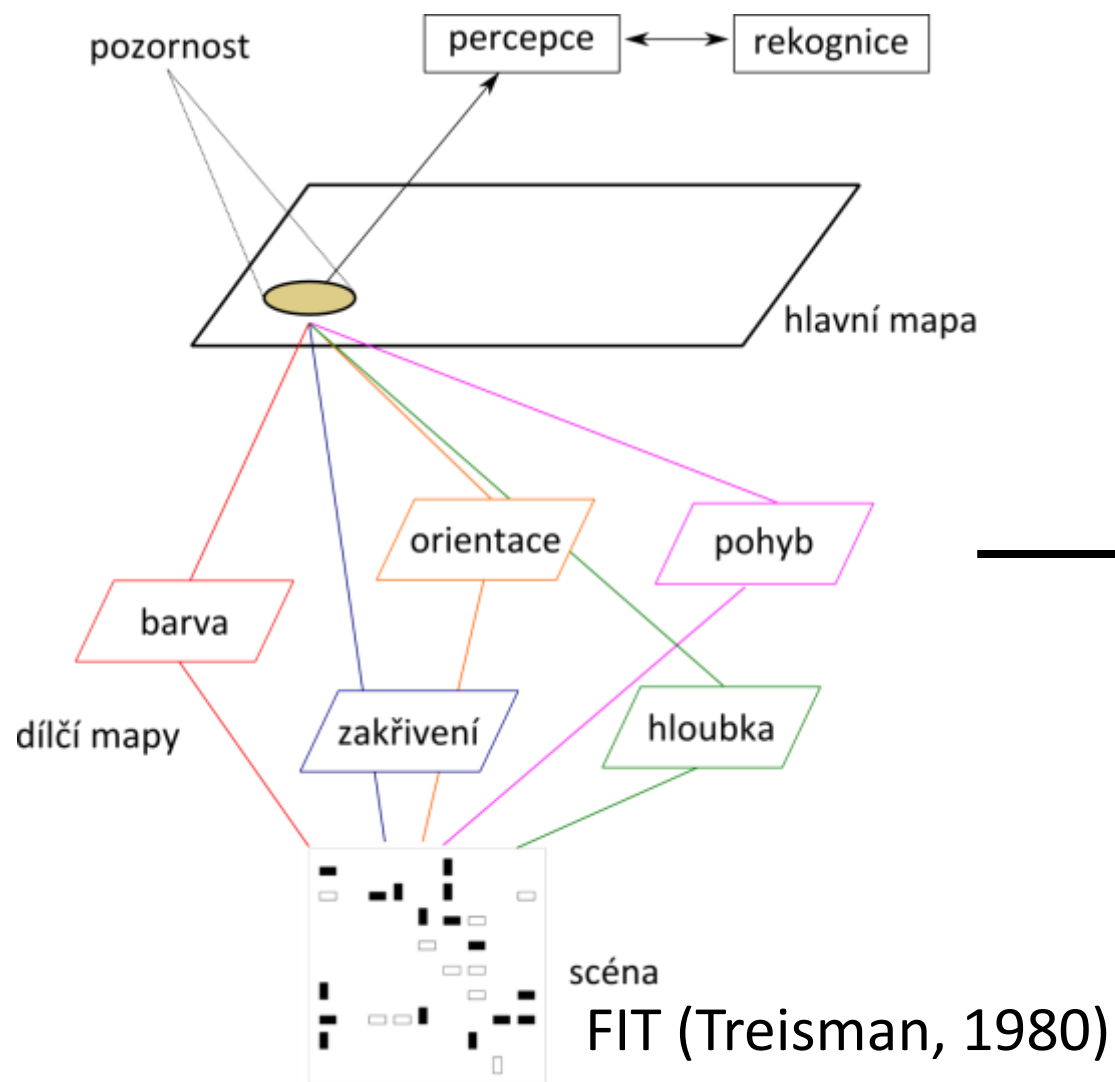
Visual Search Task



Oční pohyby můžeme měřit



Vizuální salience (Pro prvních 200 ms)

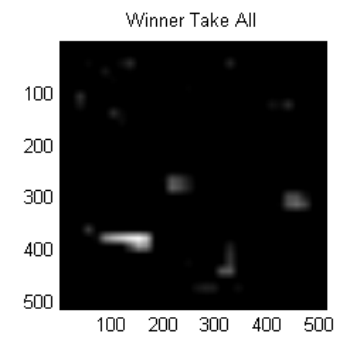
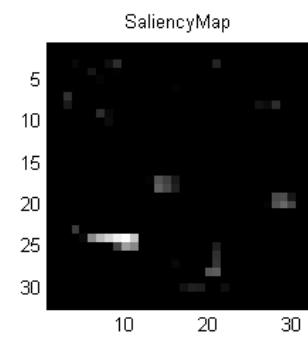
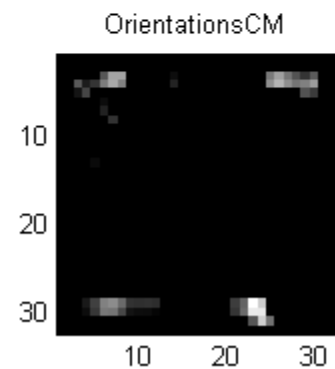
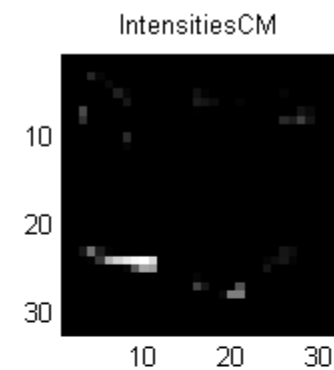
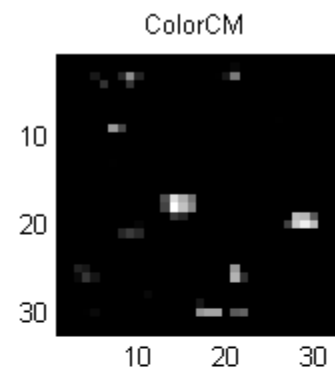


ukázka



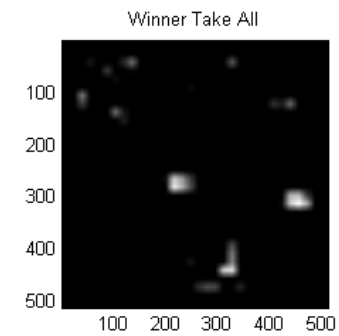
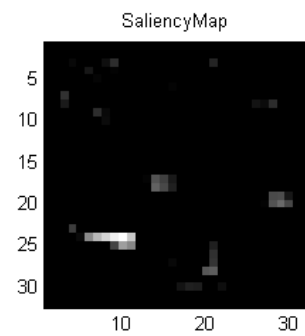
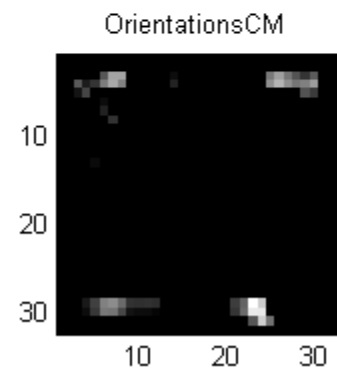
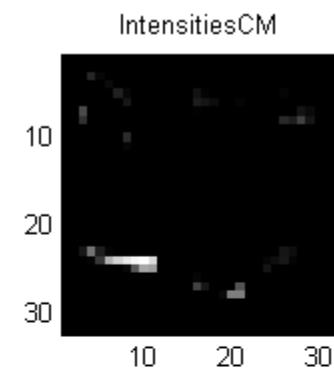
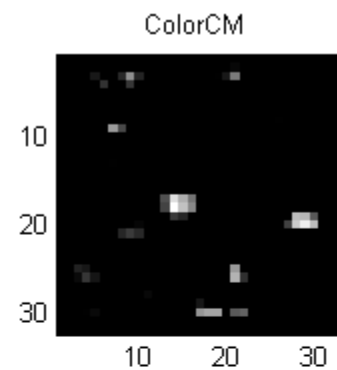
1. fixace

shape from: Intensity (7-4)



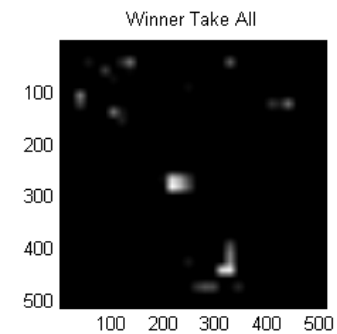
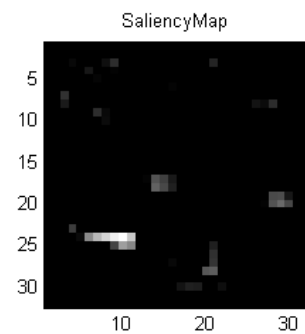
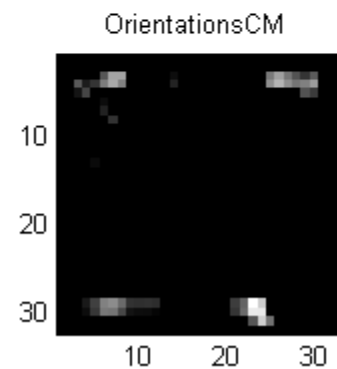
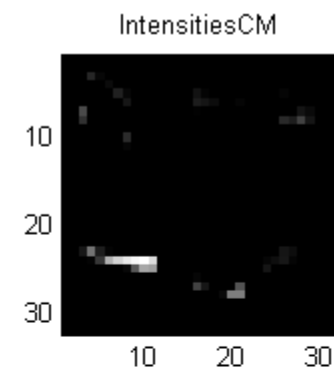
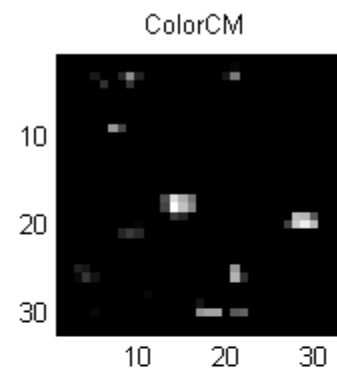
2. fixace

shape from: Blue/Yellow (7-4)



2. fixace

shape from: Blue/Yellow (8-5)



Modely vycházející z teorie detekce signálu

- Detekujeme signál (= cíl) v šumu

- Cíl: 

- Šum:

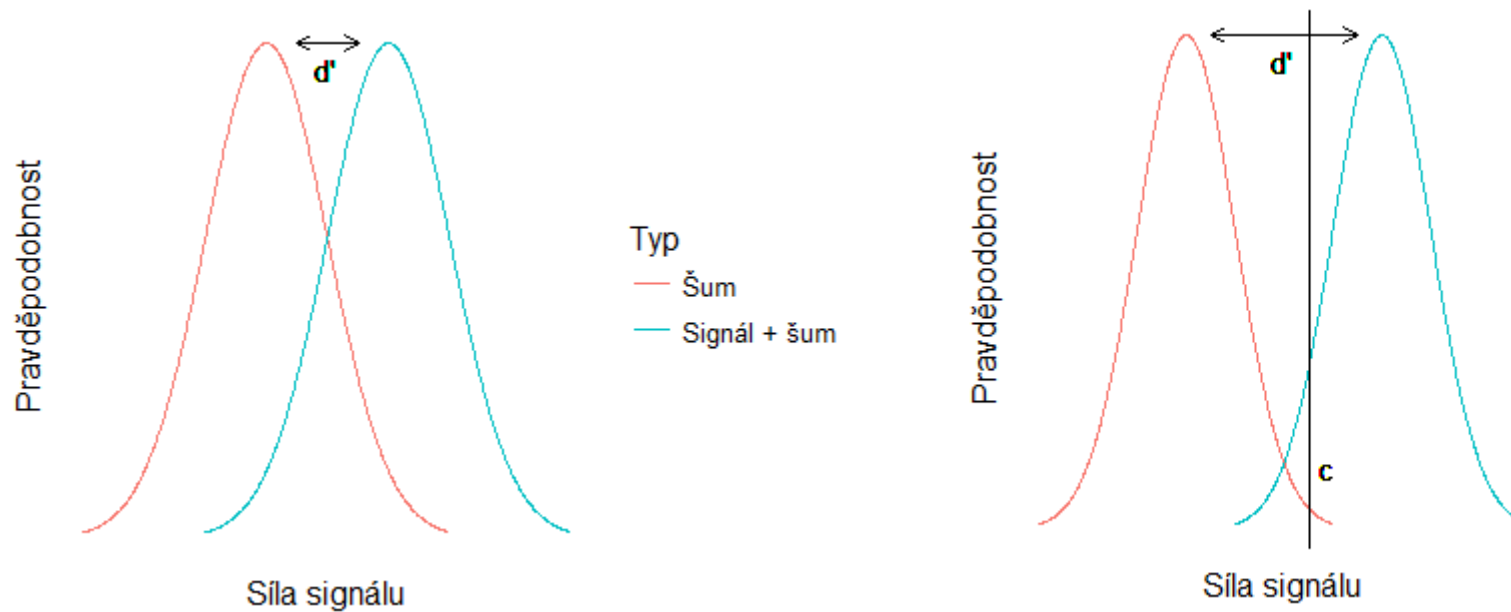


- Cíl + šum:



Teorie detekce signálu

		Odpověď	
		Viděl/a jsem cíl	Neviděl/a jsem cíl
Skutečnost	Cíl je přítomen	Hit	Miss
	Cíl není přítomen	False Alarm	Correct Rejection



d' – diskriminační index
(vyšší: lépe rozhoduji)

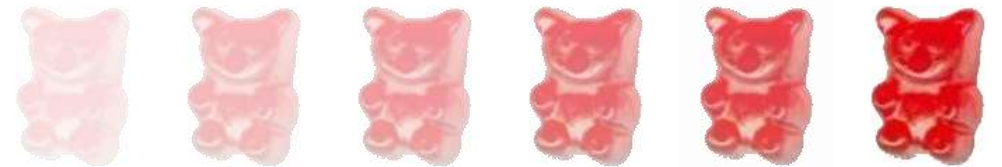
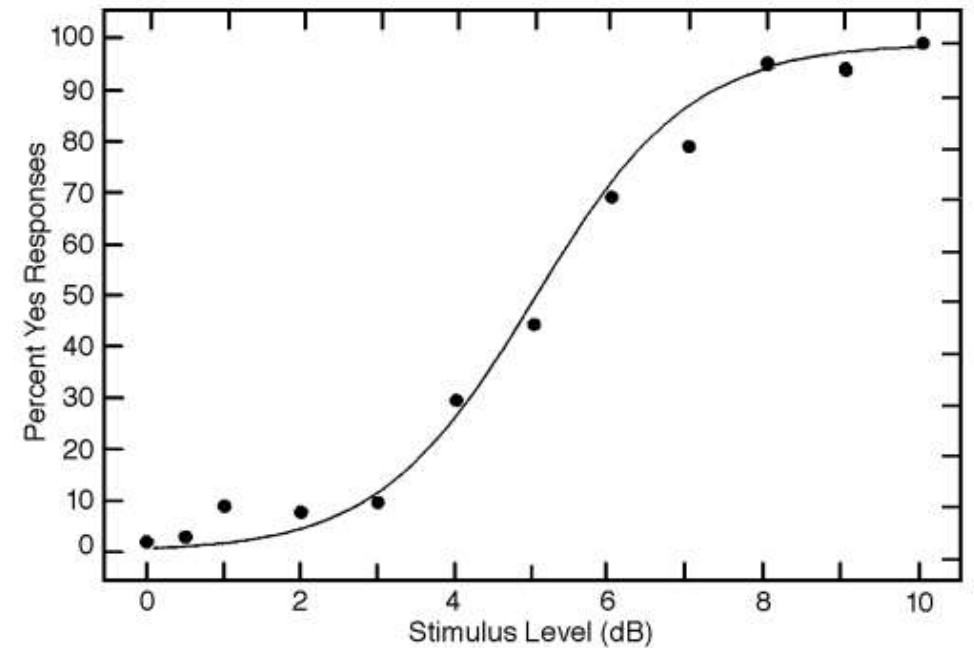
c – rozhodovací kritérium
(záporné: liberální,
kladné: konzervativní)

Psychometrická funkce

- Chceme zachytit závislost mezi intenzitou stimulu a šancí správné odpovědi

$$\psi(x; \theta, \gamma, \lambda) = \gamma + (1 - \gamma - \lambda)F(x; \theta)$$

- γ – Určuje minimální hodnotu PF. Při 2 možnostech bývá $\gamma = 0.5$ (hádání)
- λ – Určuje pravděpodobnost, že člověk udělá chybu při odpovědi. Typicky se nastaví na 0.01 (1%)
- θ – Určuje parametry příslušné použité funkce, typicky bývají dva
- Přesný tvar se hledá metodou maximální věrohodnosti



Ideální Bayseovský pozorovatel

- Ideální Bayesovský pozorovatel je teoretické zařízení, které vykonává danou úlohu optimálně vzhledem k dostupným informacím a vzhledem ke konkrétním omezením. Využívá se k:
 - *Identifikaci stimulů relevantních k dané úloze.*
 - *Popisu, jak použít tyto parametry pro úlohu.*
 - *Dává nám benchmark, vůči kterému můžeme porovnat další modely nebo lidský výkon.*
 - *Slouží pro generování hypotéz pro lidský výkon.*

Pst, že dostaneme tyto data, pokud platí tato hypotéza

Pst, že tato hypotéza platí

$$P(h|d) = \frac{P(d|h) P(h)}{P(d)}$$

data

Pst, že při daných datech platí tato hypotéza

Ideální Bayesovský pozorovatel - obecně

$$\mathbf{R} = \arg \max_r \left[\sum_{\omega} u(\mathbf{r}, \omega) p(\mathbf{S}|\omega) p(\omega) \right]$$

- ω : neznámý stav světa (např. medvídek přítomen/nepřítomen)
- S : pozorovaný stimulus (co vidí oko – nemusí být nutně přímo medvídek)
- r je odpověď systému (kam se podívat dál)
- $p(S|\omega)$ je věrohodnost daného vjemu vzhledem ke stavu světa (Bayesova věta)
- $p(\omega)$ je apriorní pravděpodobnost (Bayesova věta)
- $u(r, \omega)$ je cena odpovědi r při stavu světa ω (pohyb očí něco stojí)

Evolve jde k ideálnímu Bayesovskému pozorovateli

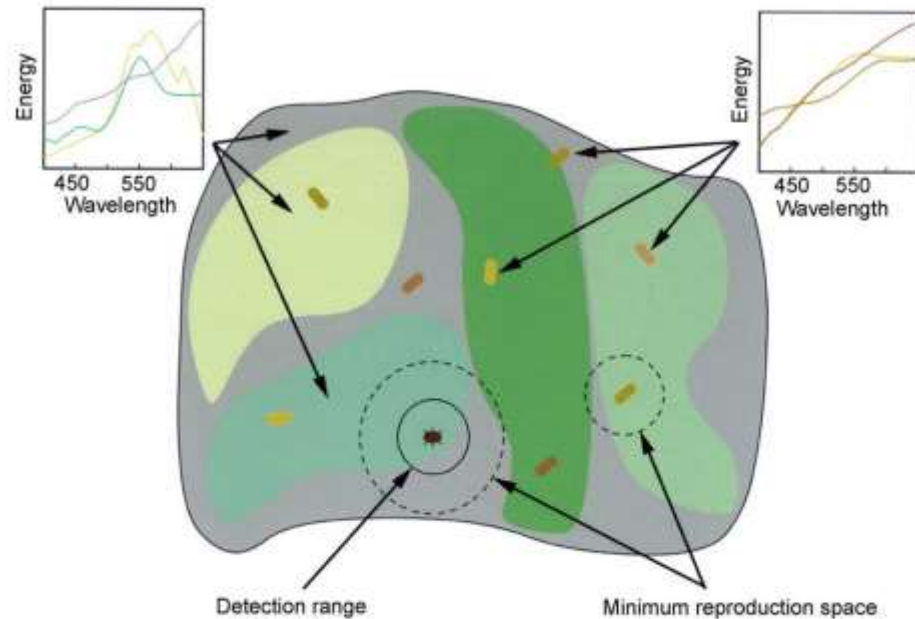


Fig. 1. A hypothetical world consisting of a mobile predator species (the six-legged organism) and a static prey species (the rod-shaped organisms) in a simple environment. The insets illustrate representative chromatic spectra arising from the background and from the surface of the prey. The dashed circles indicate minimum reproduction spaces, which set the maximum density of predators and prey that the environment could support under the best of circumstances (for each species considered separately). The solid circle represents the effective detection range of the predator's sensory system.

$$\bar{O}_a(t+1) = O_a(t) \sum_{\omega} p_a(\omega; t) \sum_r \gamma_a(r, \omega) \sum_s p_a(r|s) p_a(s|\omega)$$

Labels for the equation:

- $\bar{O}_a(t+1)$: Number of organisms
- $O_a(t)$: Alleles
- $\sum_{\omega} p_a(\omega; t)$: Prior probability
- $\sum_r \gamma_a(r, \omega)$: Growth factor
- $\sum_s p_a(r|s) p_a(s|\omega)$: Stimulus likelihood and Response likelihood

Fig. 4. The fundamental equation of Bayesian natural selection shows how the expected number of organisms of a given species carrying a given vector of alleles a at time $t + 1$ is related to the number of organisms carrying the same alleles at time t . Each different vector of alleles in each species under consideration is represented by a separate fundamental equation; all of the equations are evaluated and iterated in parallel. Probability distributions for actual births, actual deaths, mutation, and sexual reproduction are described by other equations.

Ukázka Ideálního pozorovatele

- Na monitoru se budou postupně zobrazovat tečky, odhadněte střed zdroje



X

+

X

X + X

X

x

x

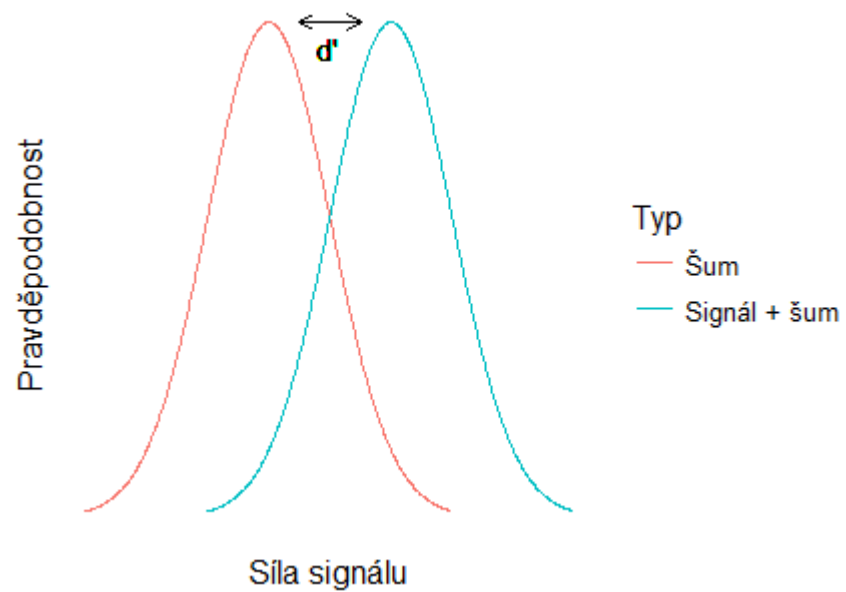
+

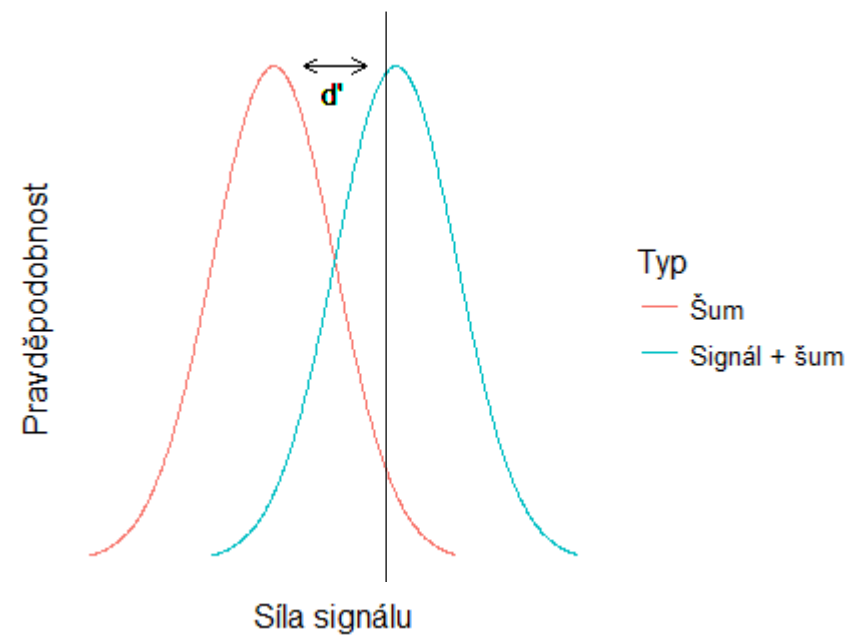
x

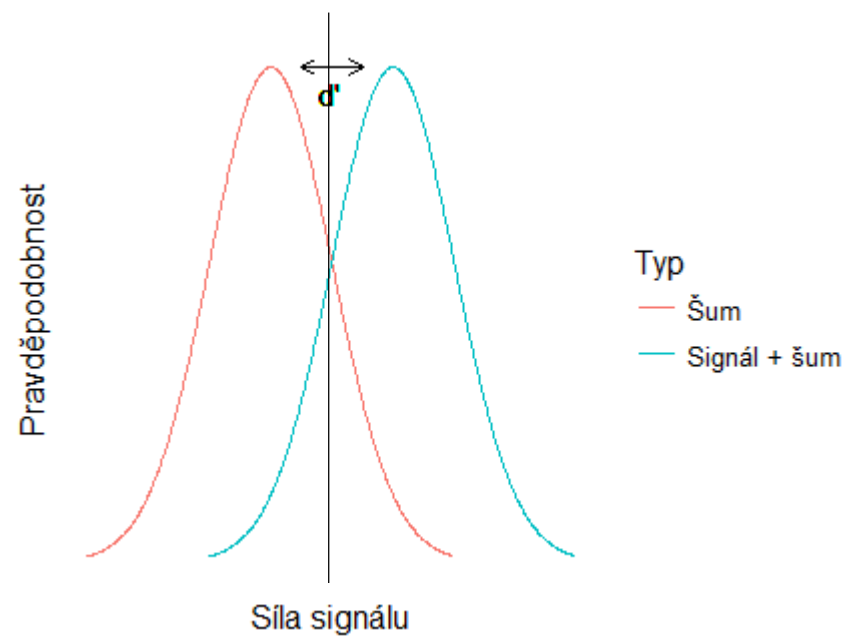
x

Další ukázka

- Kam dát kritérium pro optimální rozhodování?

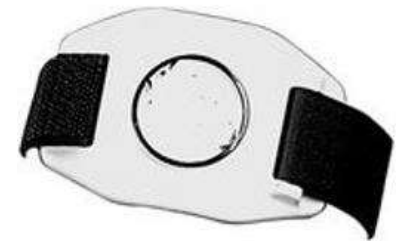
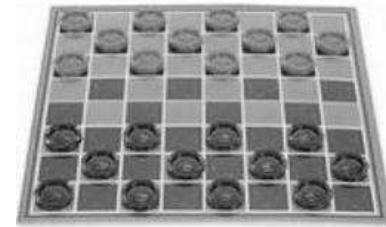




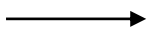


Ideální Bayesovský pozorovatel pro zrakové vyhledávání

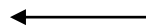
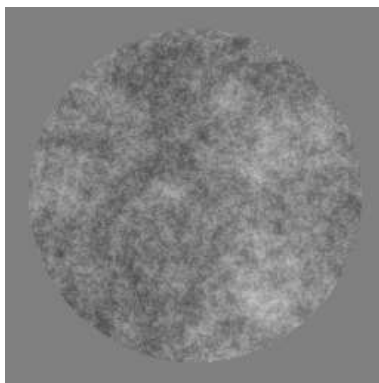
Scény i cíle jsou moc rozmanité..



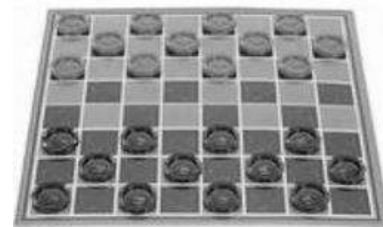
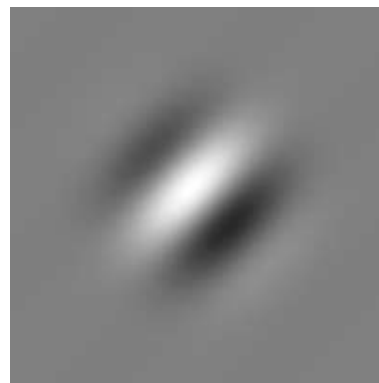
...použijeme stimuly se stejnými vlastnostmi!



šum $1/f$

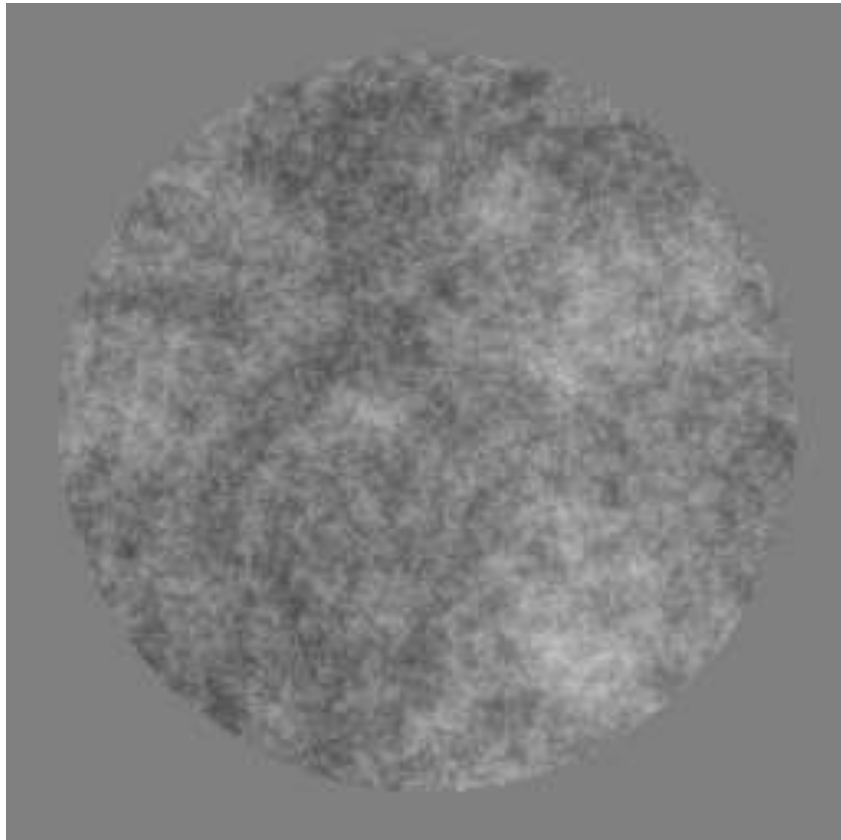


gabor patch



Lehká úloha

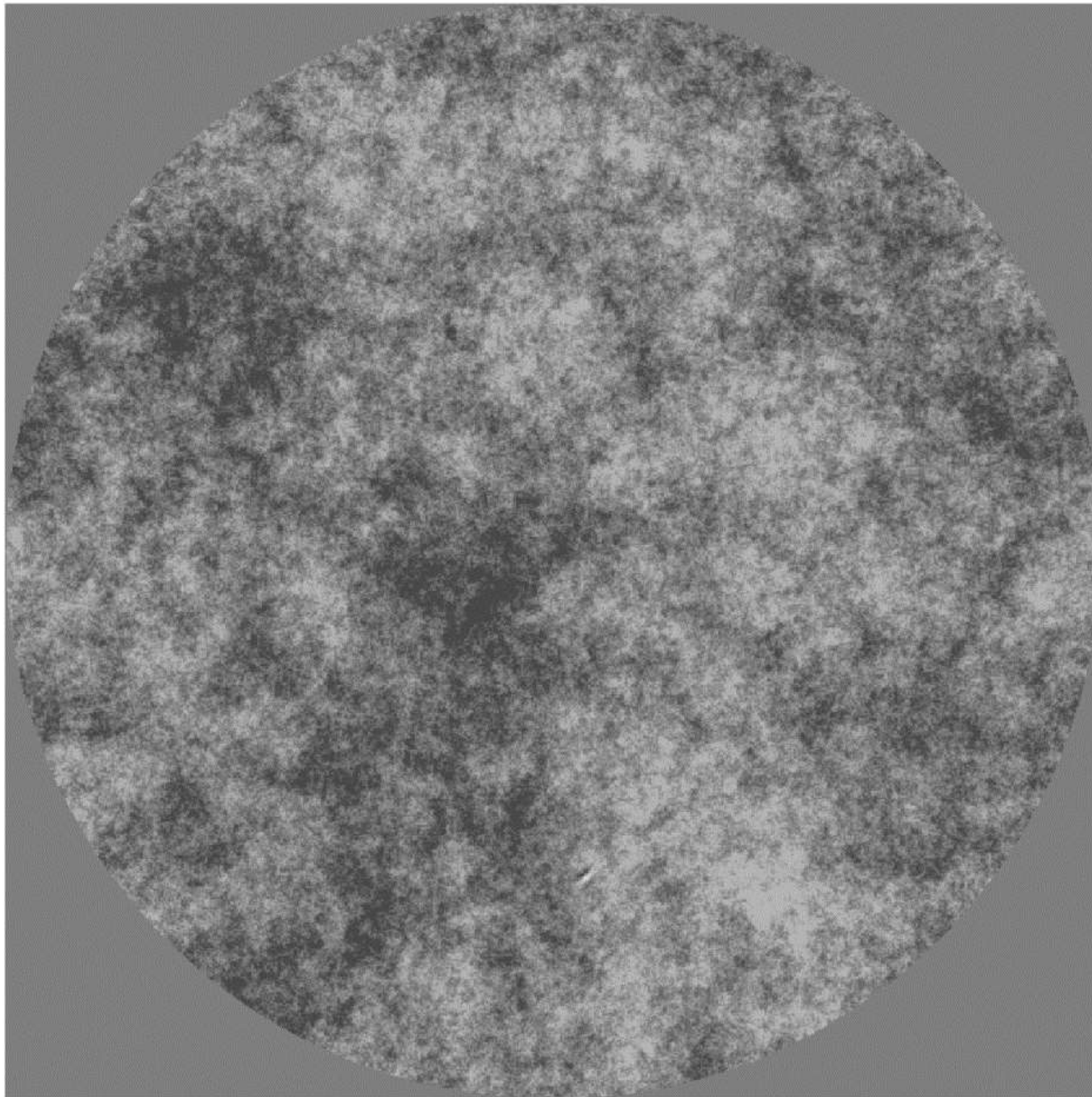
- Najděte Gaborův cíl v šumu

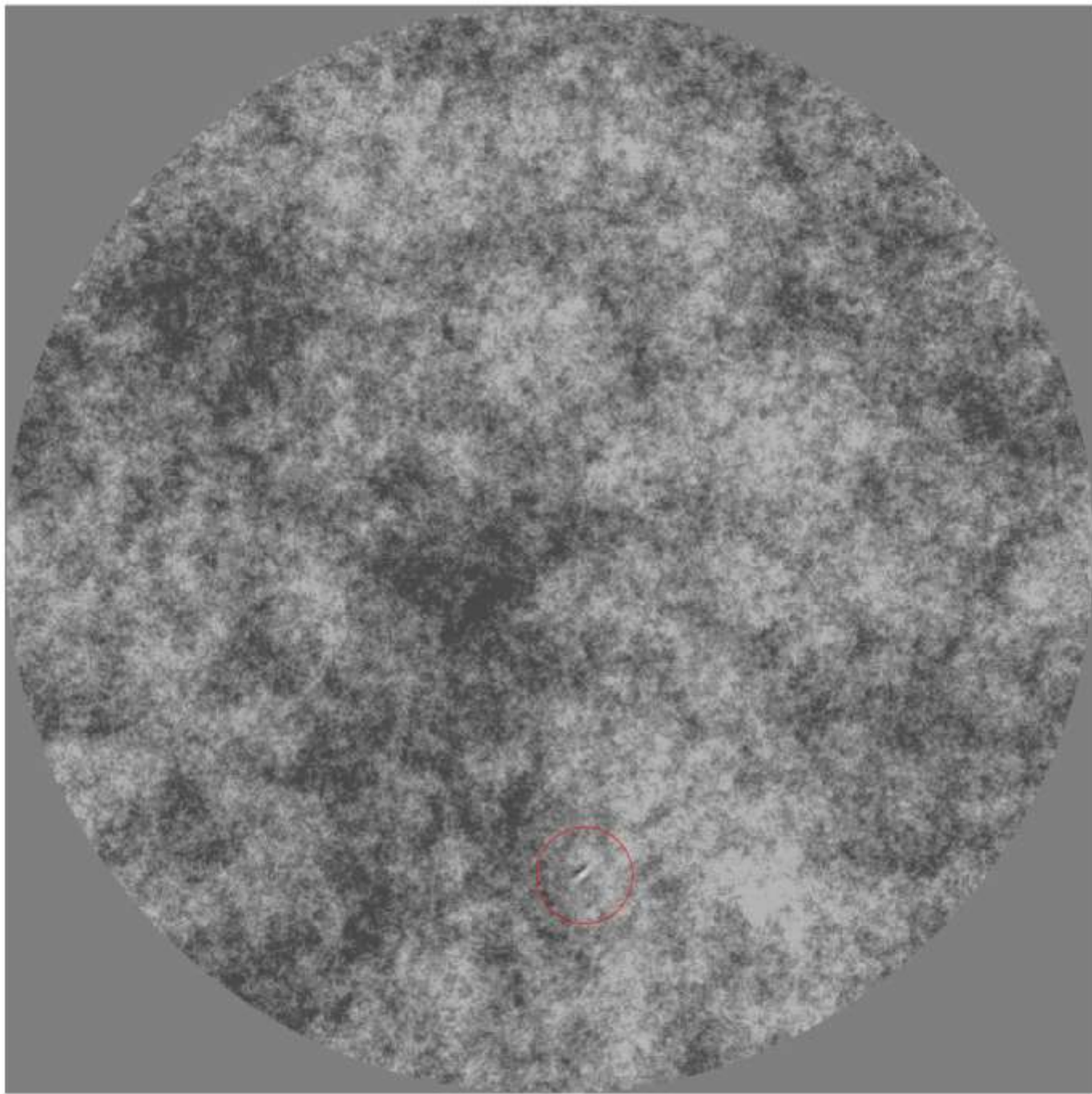


?





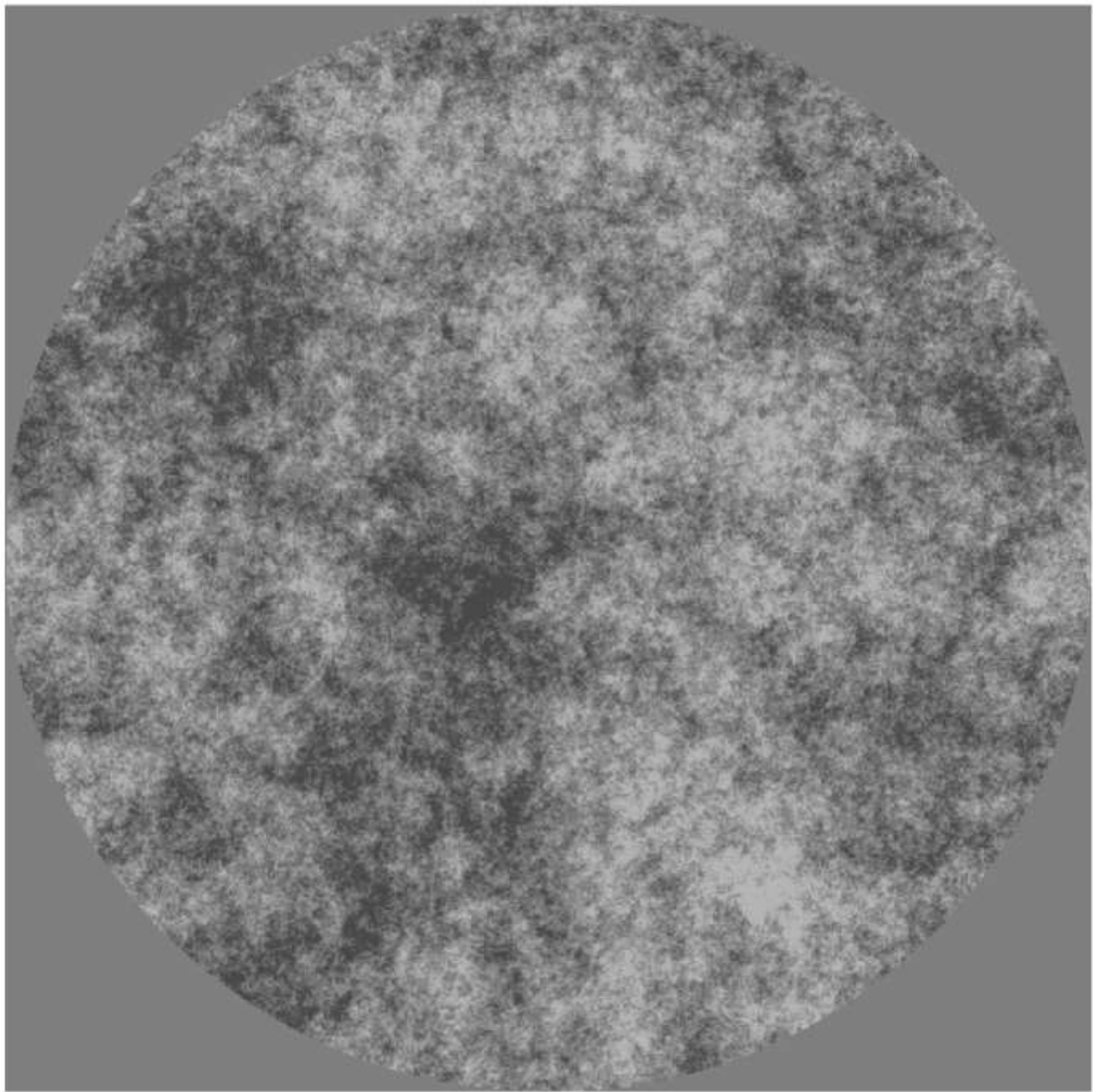


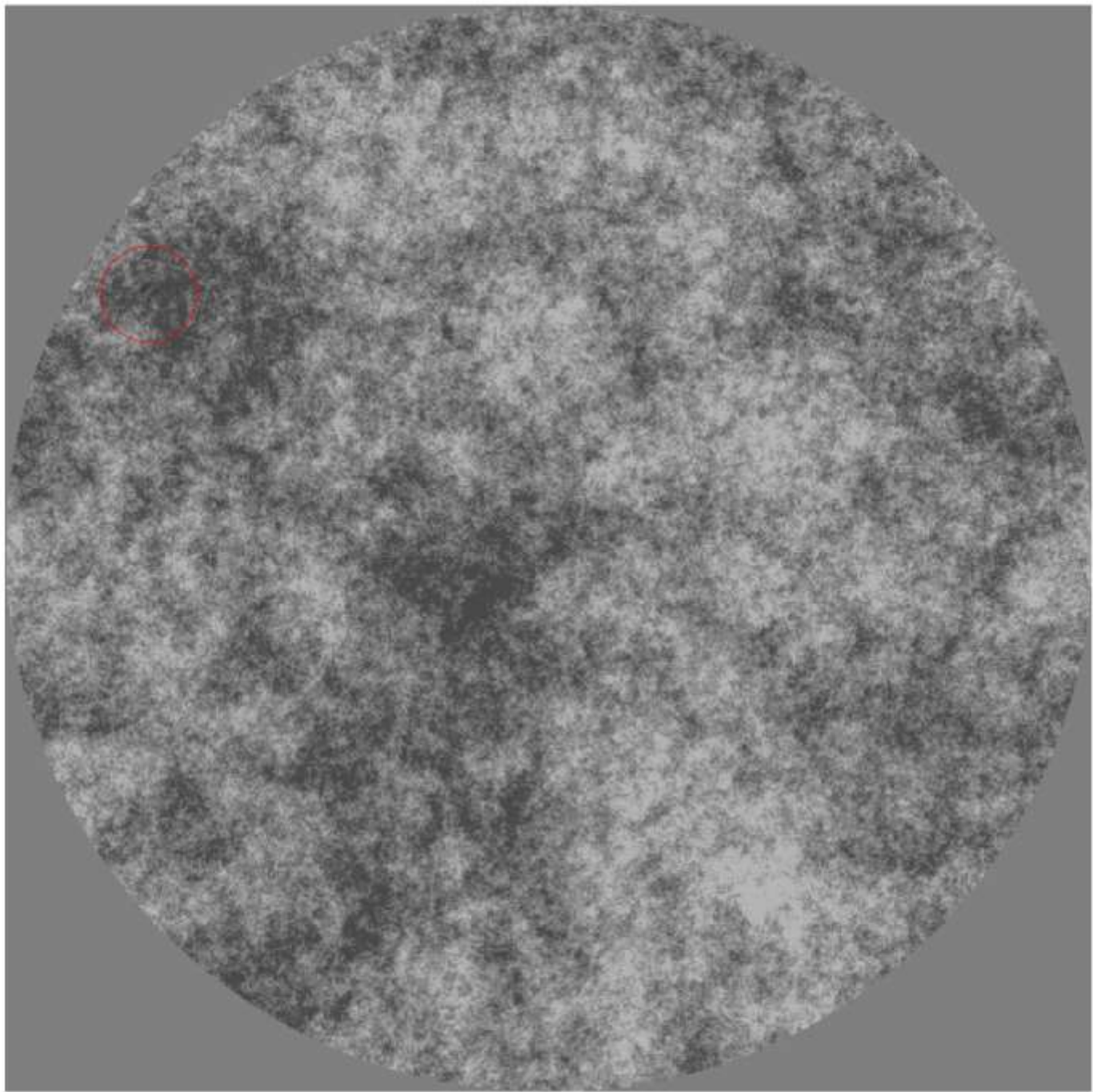


Těžká úloha

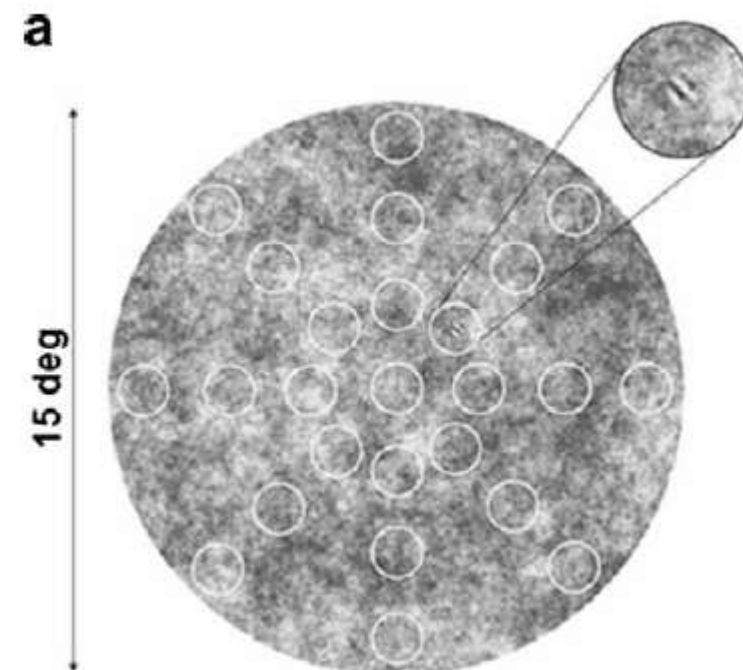
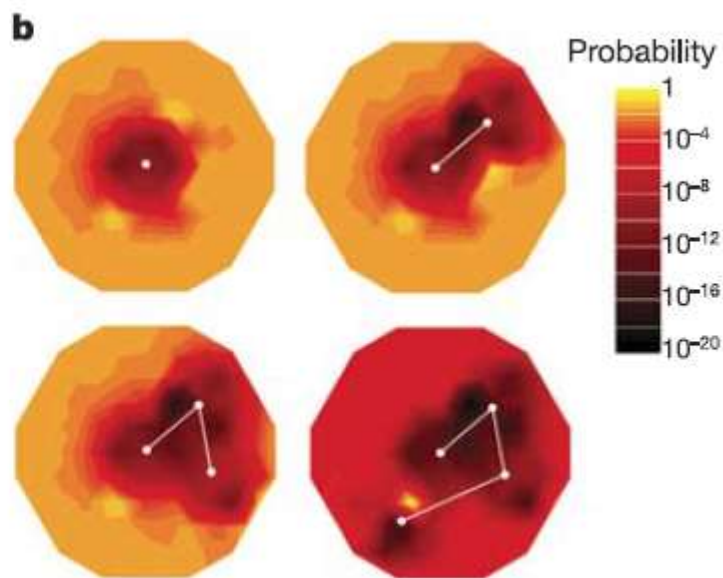
- Najděte Gaborův cíl v šumu



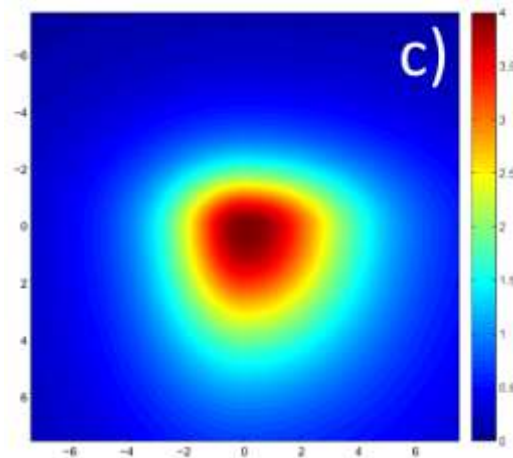




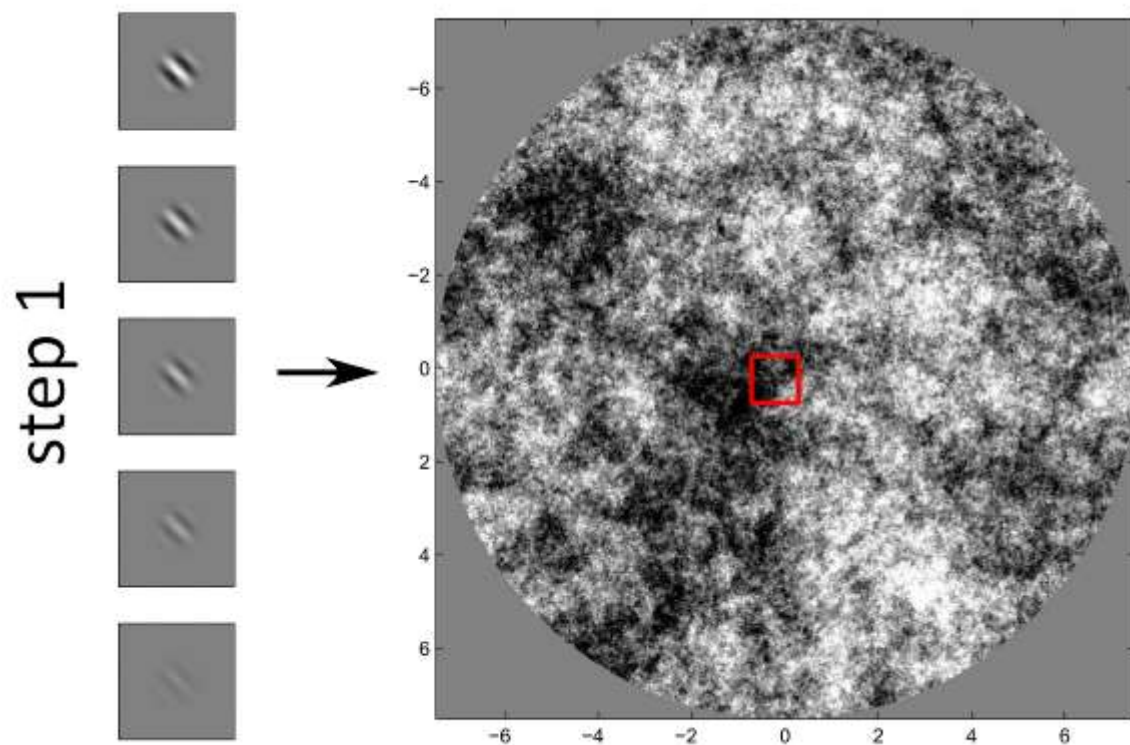
Ideální Bayesovský pozorovatel



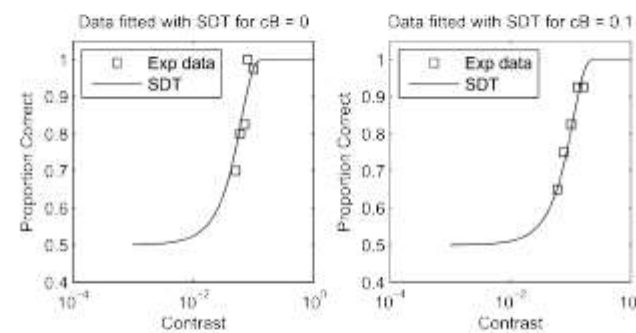
$$|k_{\text{opt}}(T + 1) = \arg \max_{k(T+1)} \left(\sum_{i=1}^n p_i(T) p(C|i, k(T + 1)) \right)$$



Odvození d' mapy – krok 1

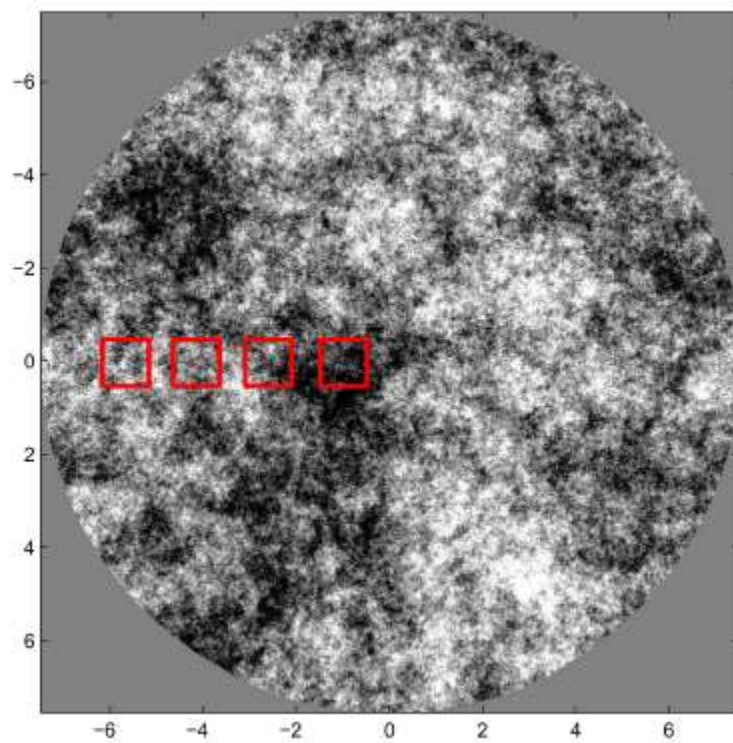


→ fit data → fix d'

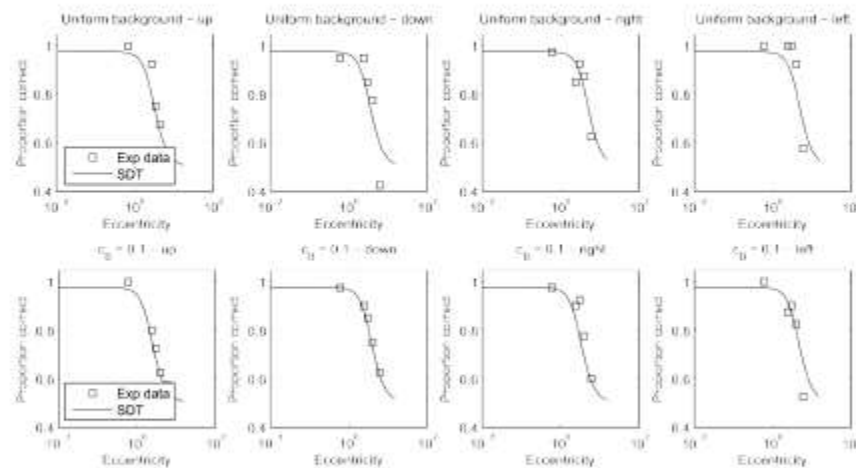


Odvození d' mapy – krok 2

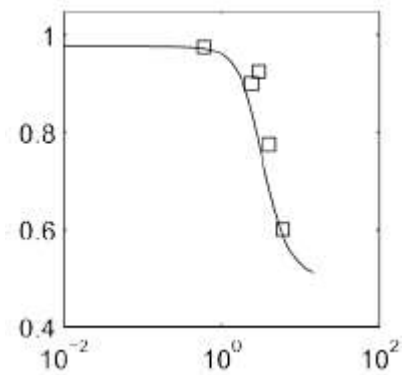
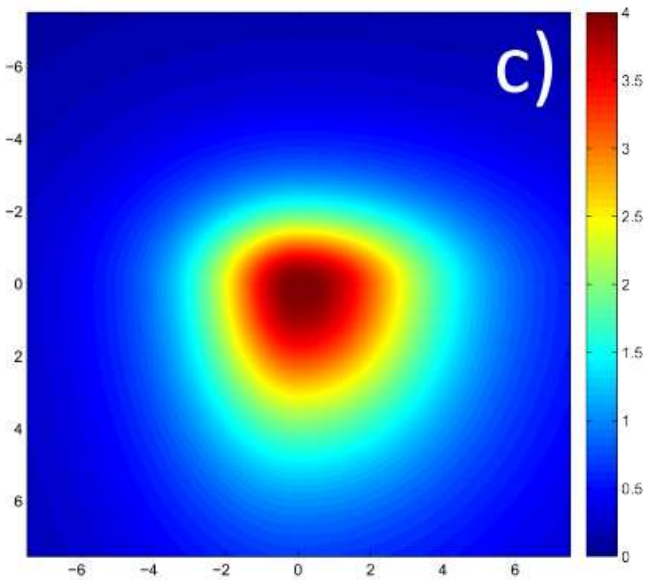
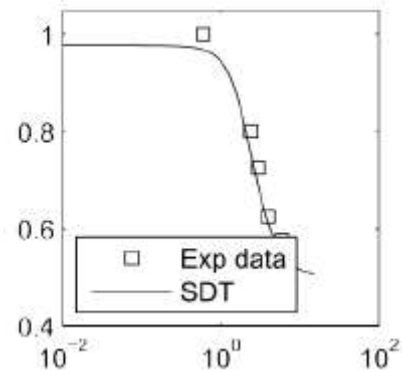
step 2

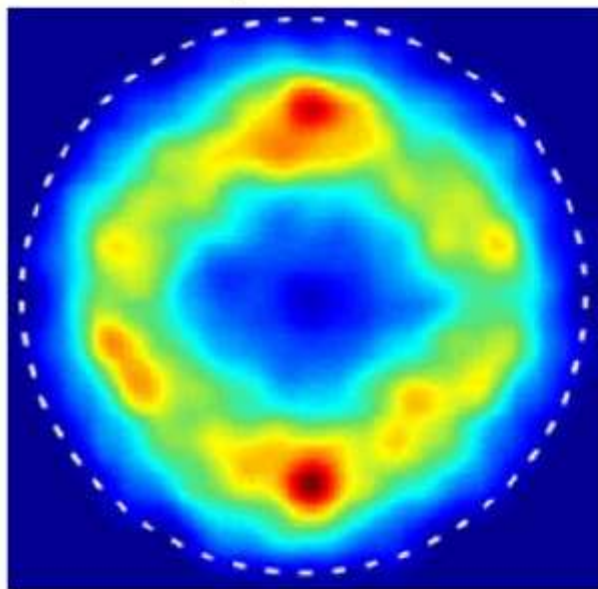
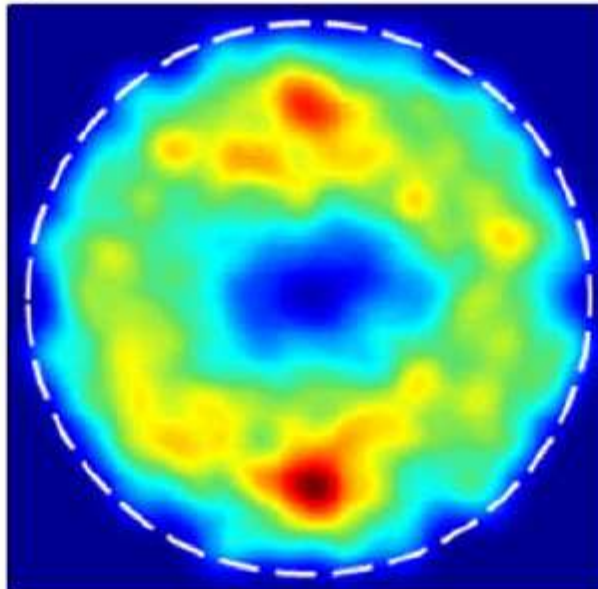
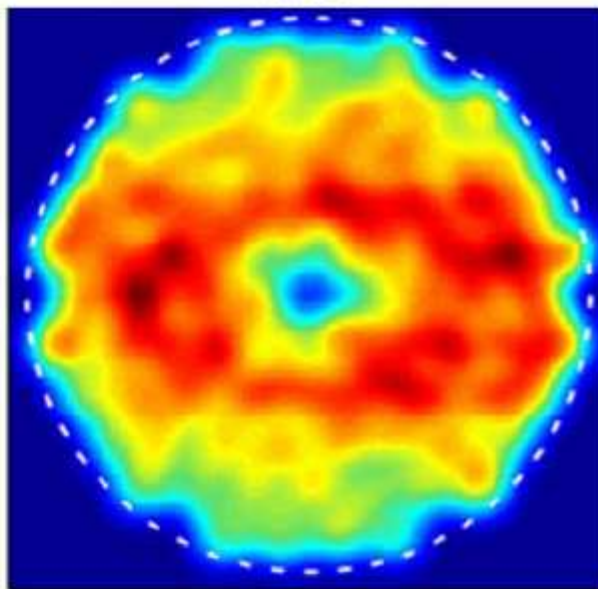
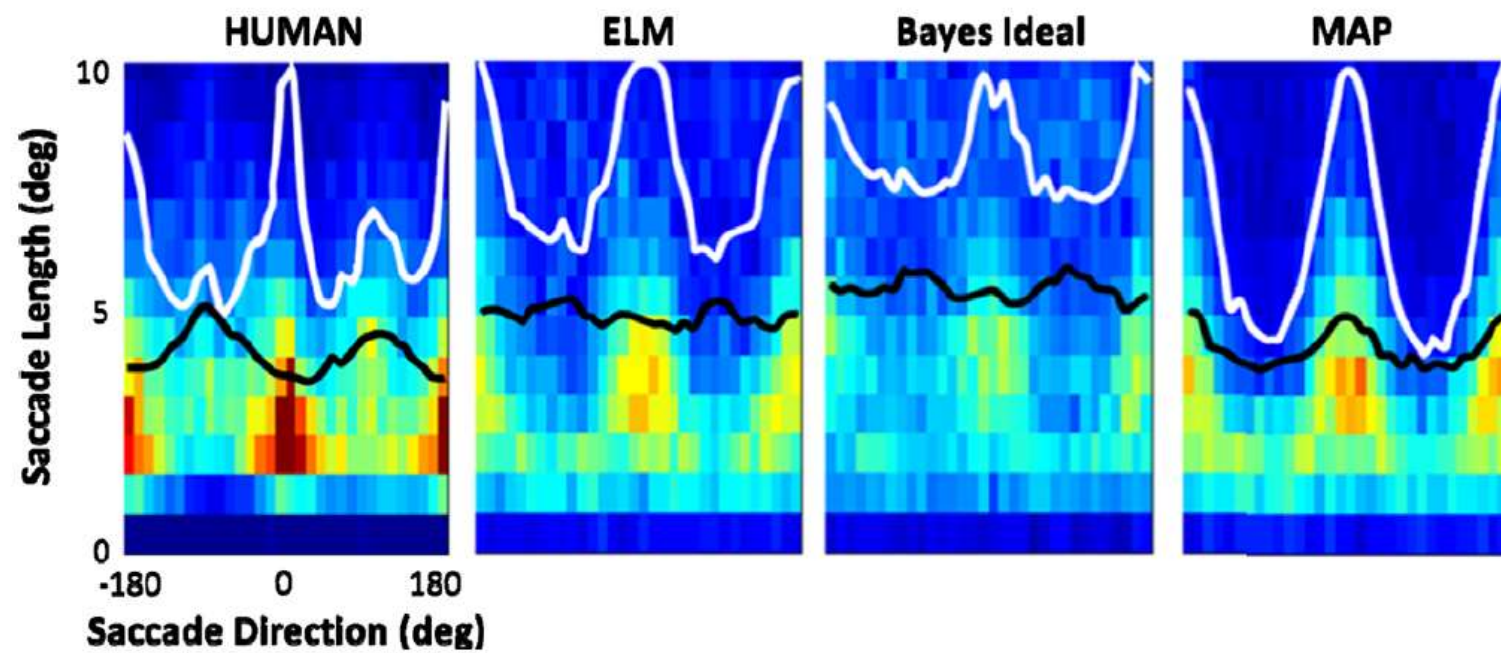
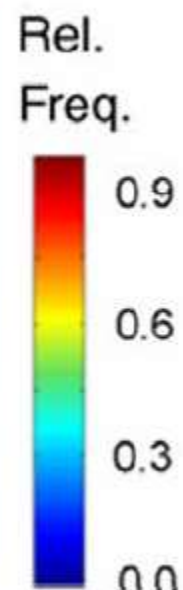
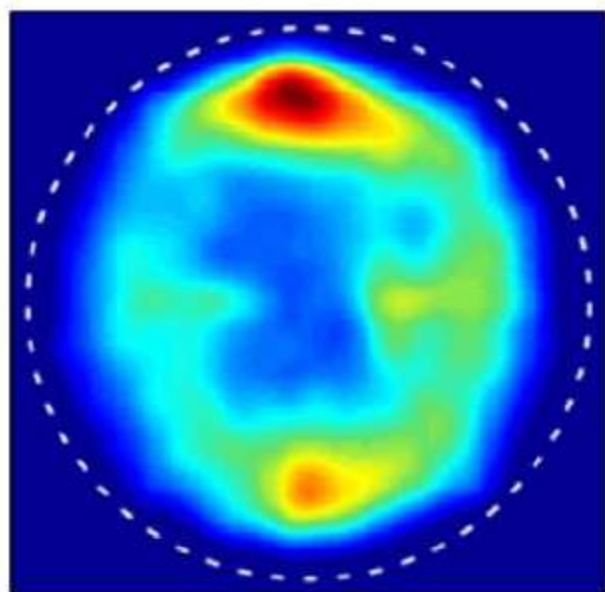


→ fit data (4 directions)



Odvození d' mapy – krok 3



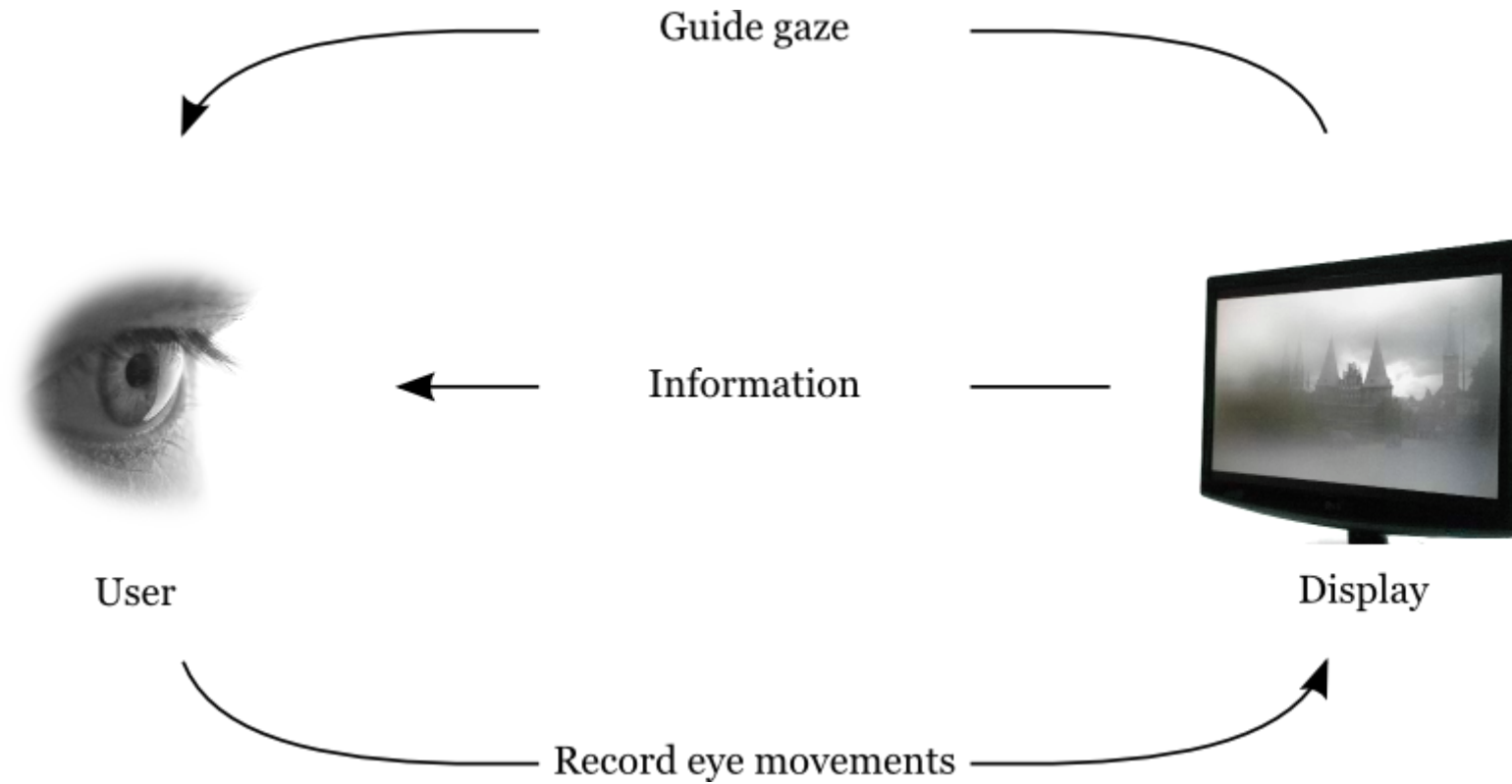
a Bayes Ideal**b** ELM**c** MAP**d** Human

Ideální Bayesovský pozorovatel pro zrakové vyhledávání
při simulované centrální skotomě

Makulární degenerace

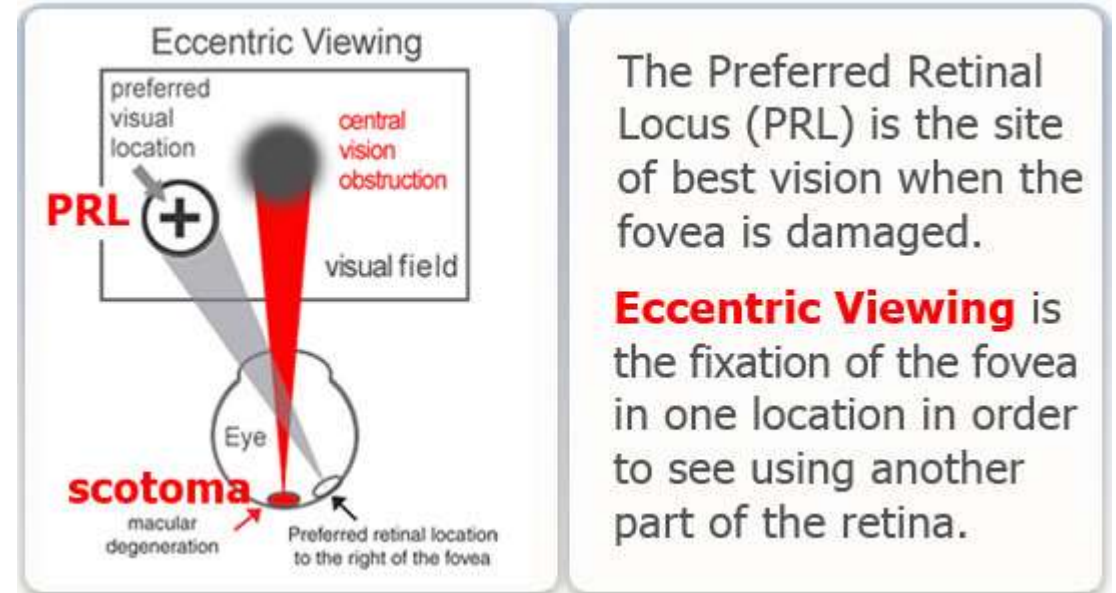


Gaze-contingent displays



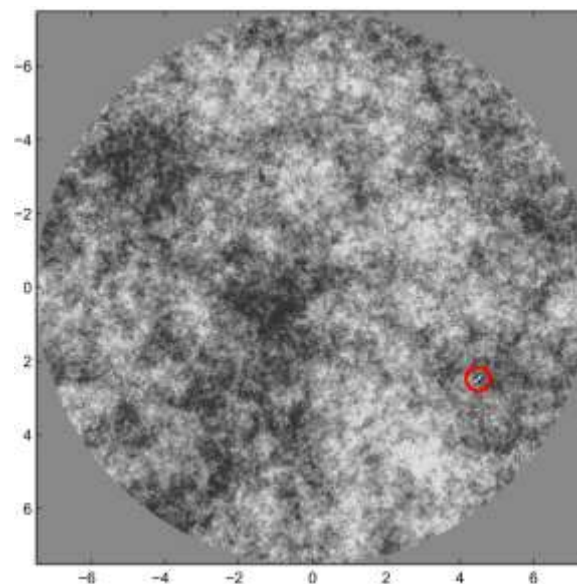
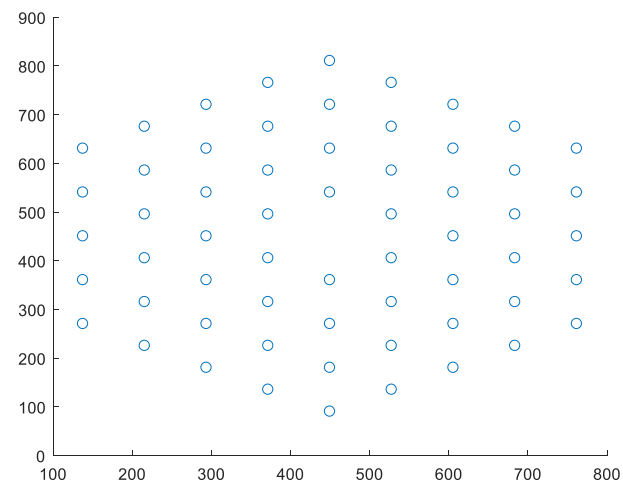
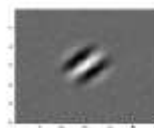
Preferred retinal locus

- Zlepšení tréninkem až o 250% při zrakovém vyhledávání
- Zlepšení u čtení z 9 slov za minutu na 68 slov za minutu
- Ale trvá to (ustálení PRL samovolně

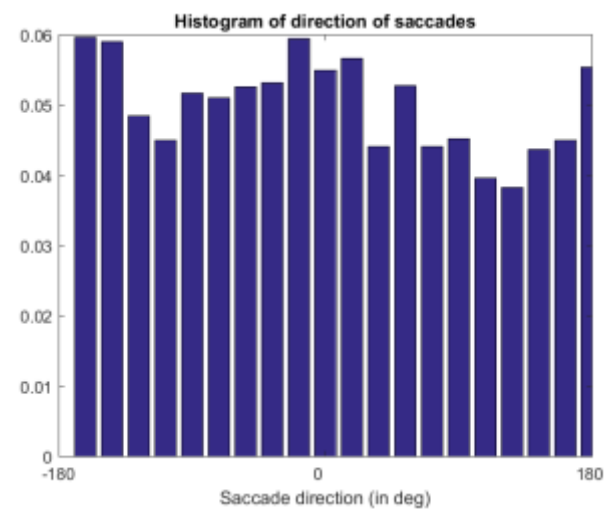
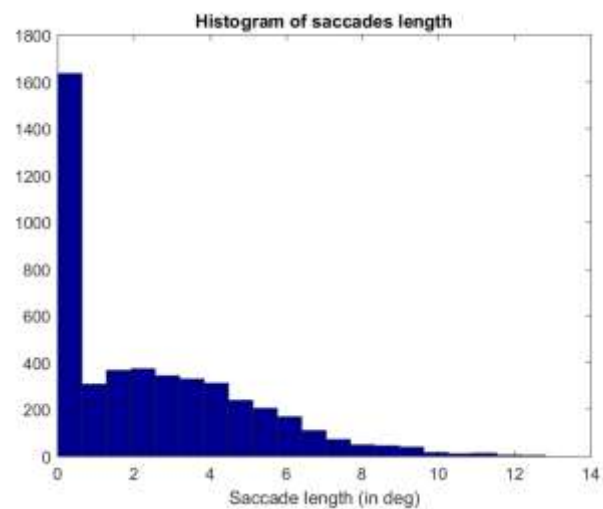
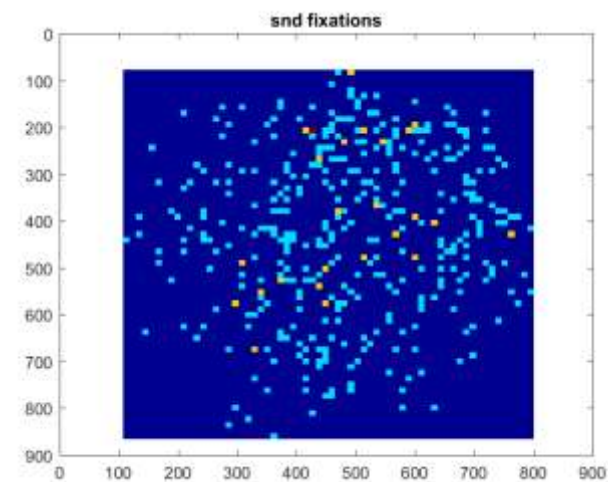
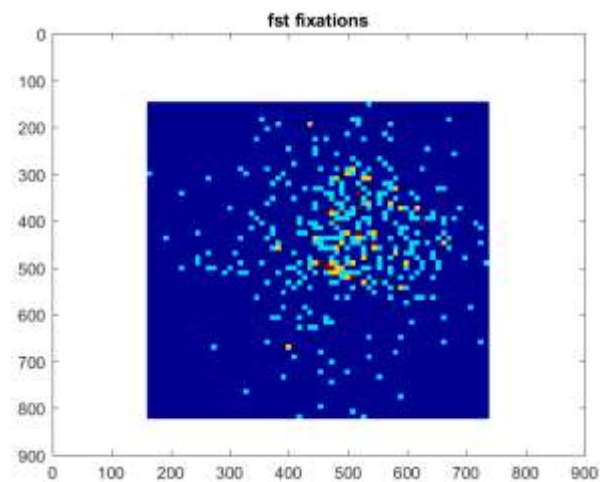
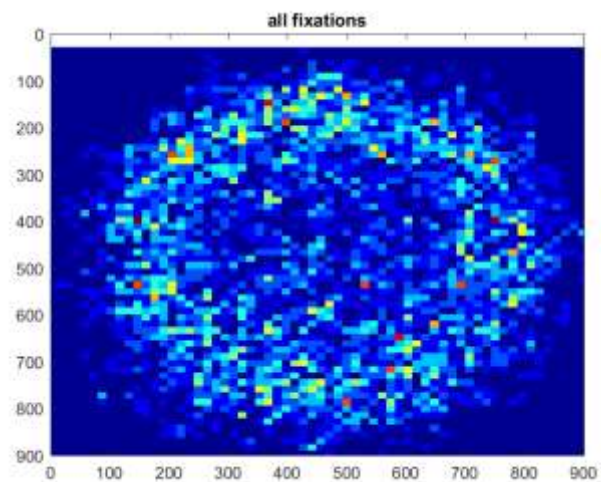


Zrakové vyhledávání – normální podmínky

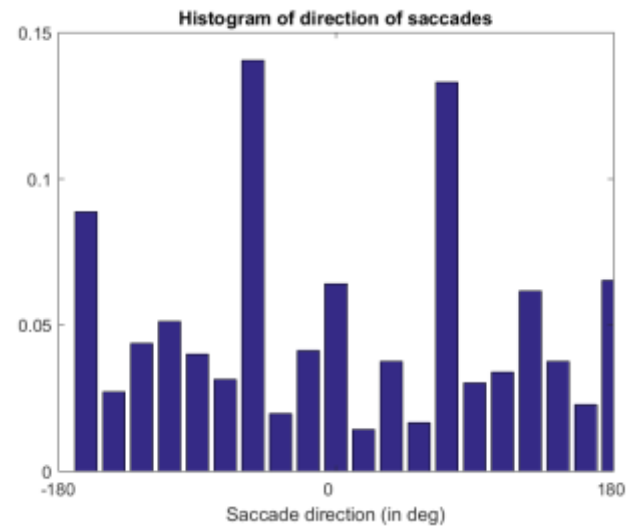
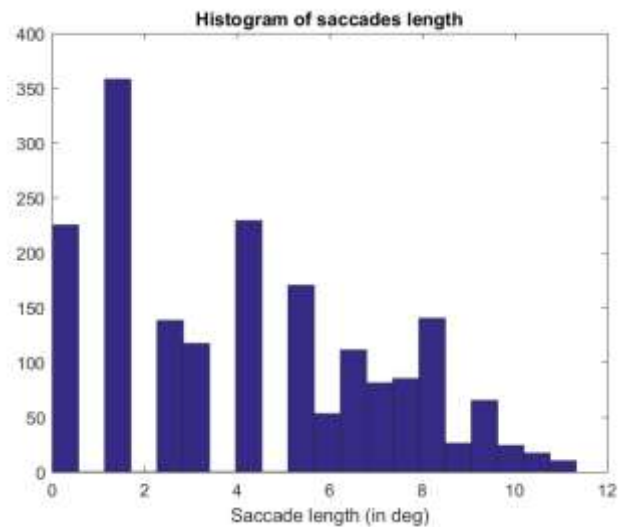
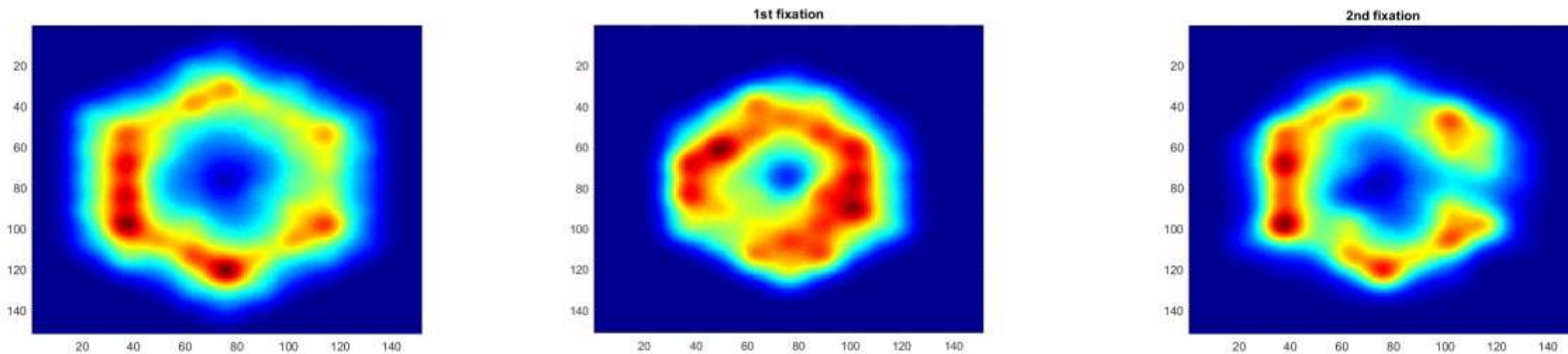
- Jeden subjekt
- N = 400 trialů
- 1/f šum, r.m.s. kontrast = 0.1
- Cíl: Gaussian (6 c.p.d)
+ raised cosine envelope
- Eyelink 1000



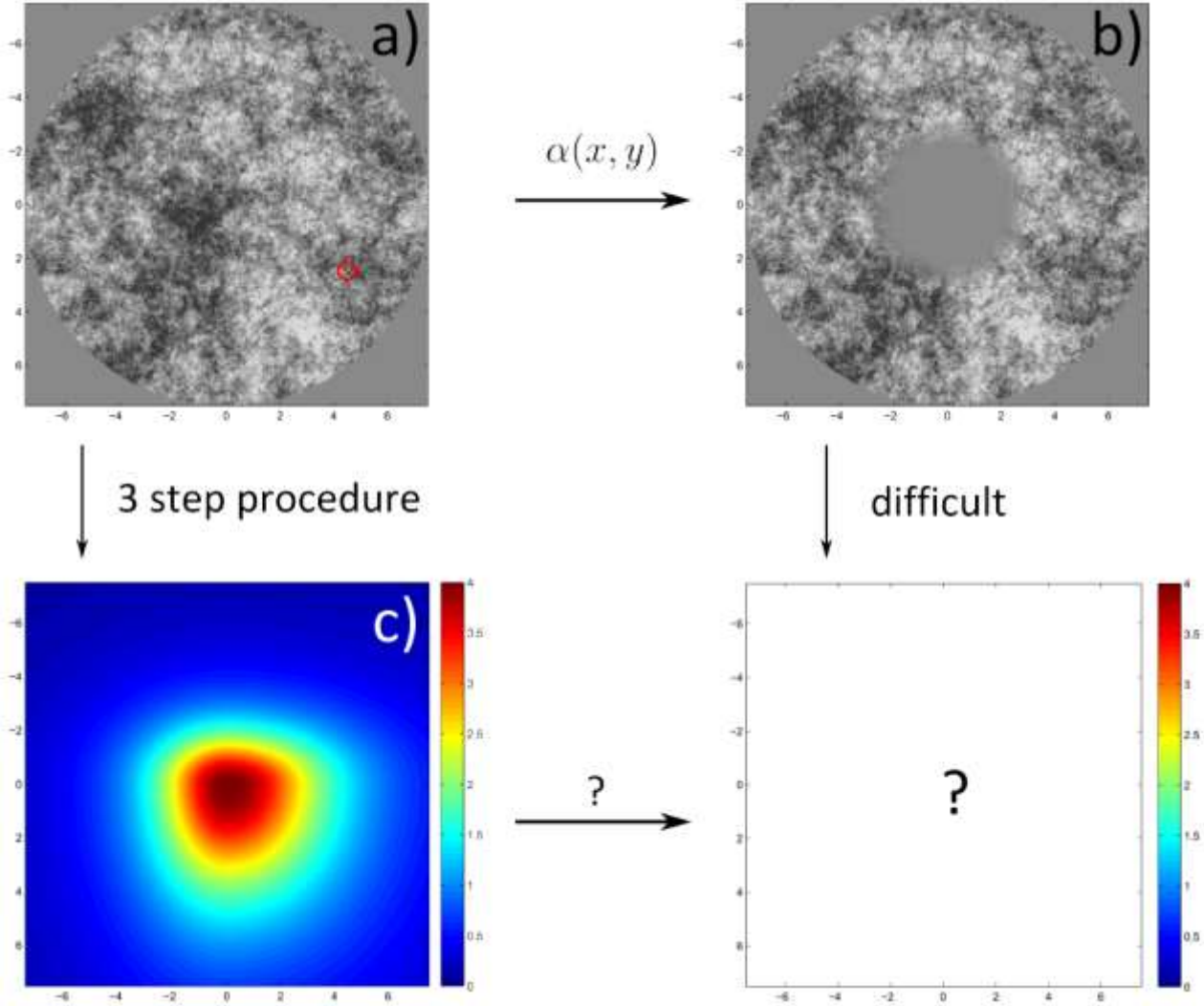
Výsledky – oční pohyby



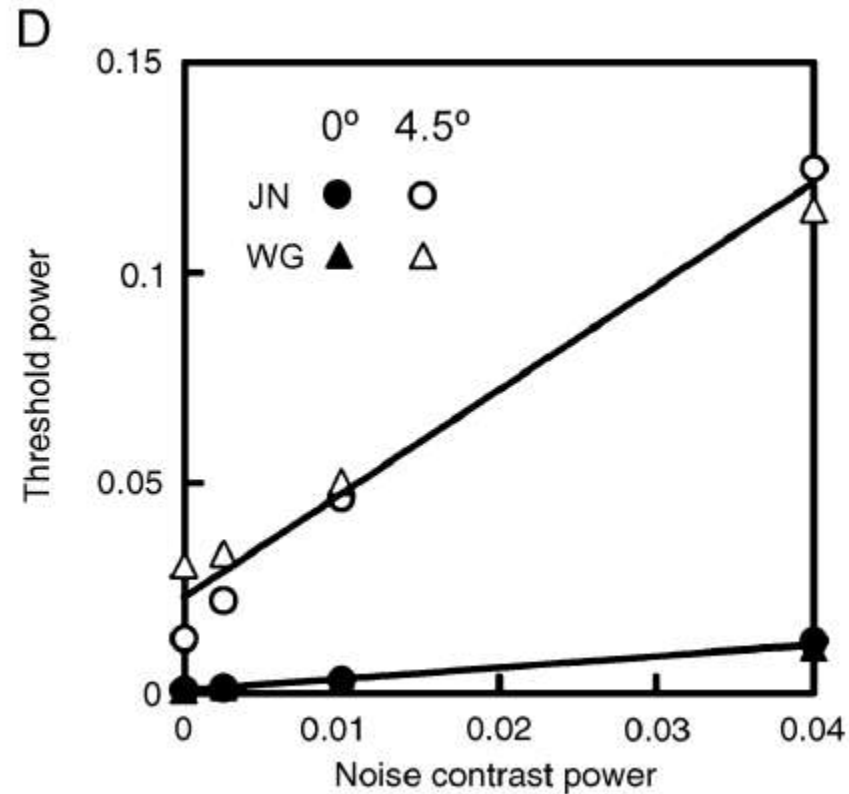
Výsledky – ELM



Jak na centrální scotomu



Modifikace masky



$$c_T^2(x, y) = K_1(x, y) \cdot c_B^2(x, y) + K_2(x, y)$$

