Using mouse tracking to study visual search

Institute for neural Computation
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Motivation

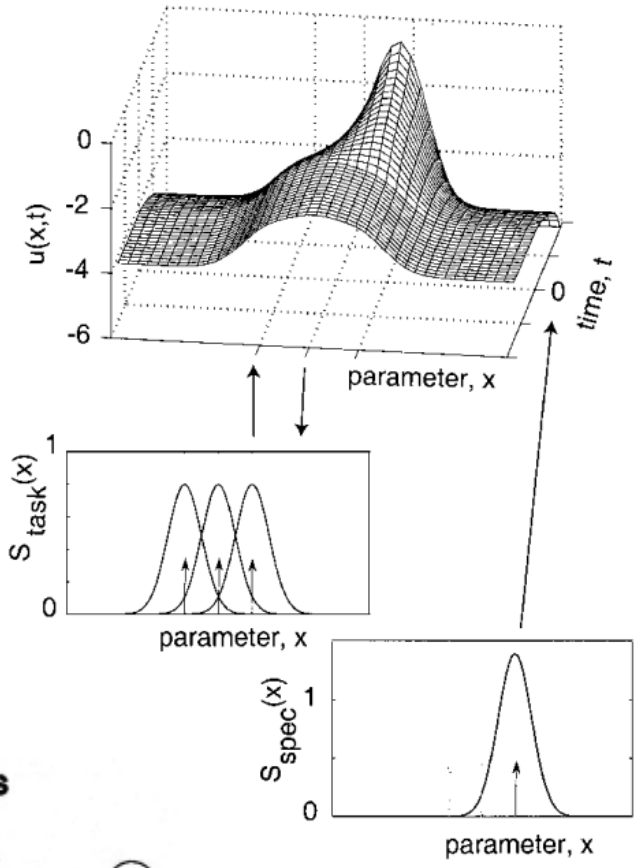
Perception, action and movement execution all happen in parallel

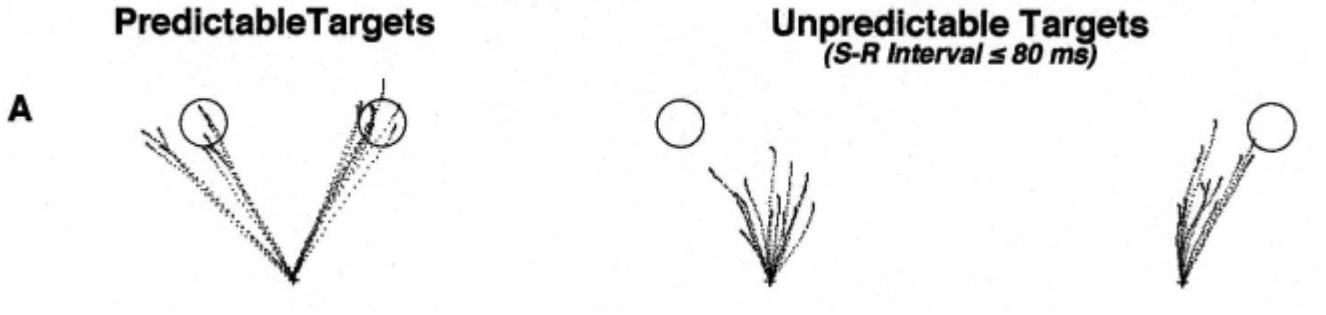
- Motor and cognitive brain areas are tightly interlinked
  [Cisek and Kalaska, 2005]
- Motor plans continuously feed into the motor system
  [Freeman, 2011]

=> Motion data allows us to infer cognitive processes

Target-orientated Movements

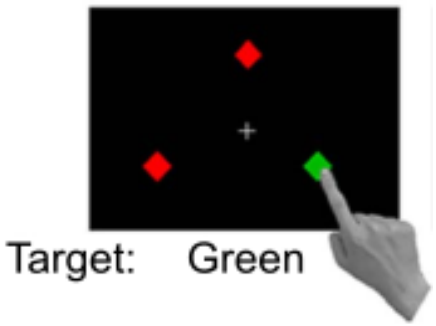
- Movement plans evolve continuously over time [Ghez et al., 1997]
- multiple possible movements specified simultaneously
- shorter planning interval:
  - ➔ movement into a default direction

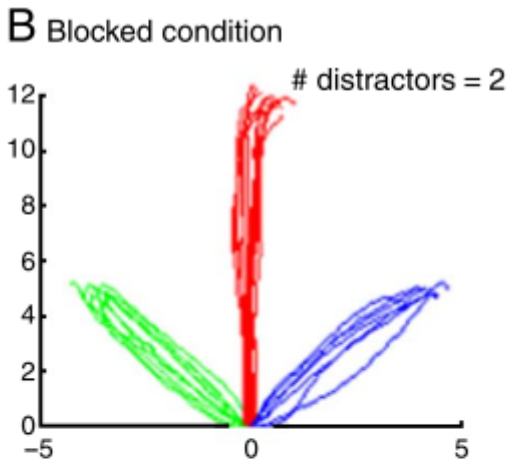


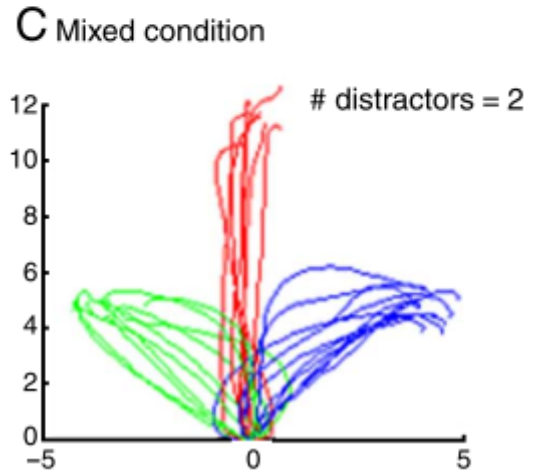


Target-oriented movement

- pointing trajectories are biased towards potential target locations
  - Probability of Target distribution [Chapman 2010]
  - Odd-one-out search [Song and Nakayama, 2008]

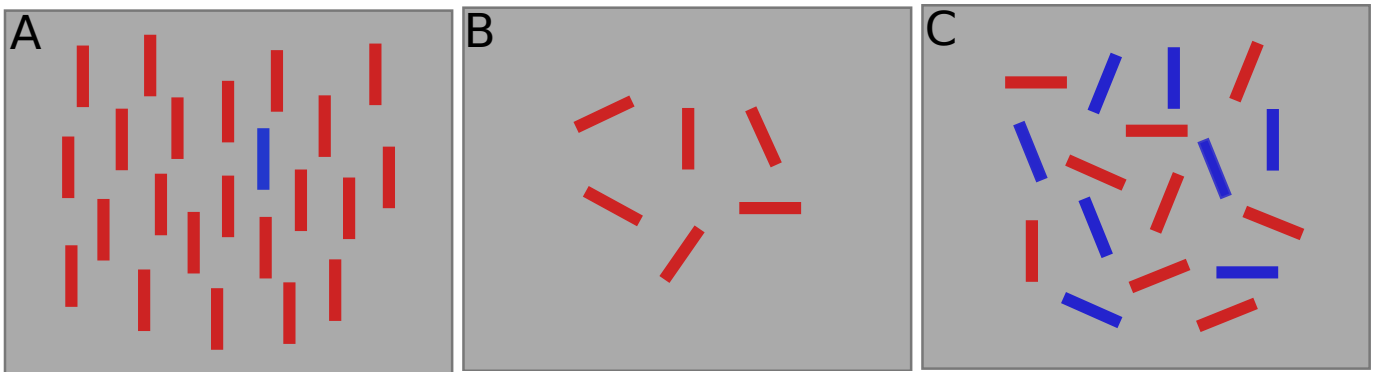






Visual attention in motor control

- Guided search [Wolfe, 2011]:
  - Guiding features are processed in parallel in Preattentive stage some
  - Attention selects targets in 2nd stage
  - Certain guiding Features: Color, Orientation, Size, Motion

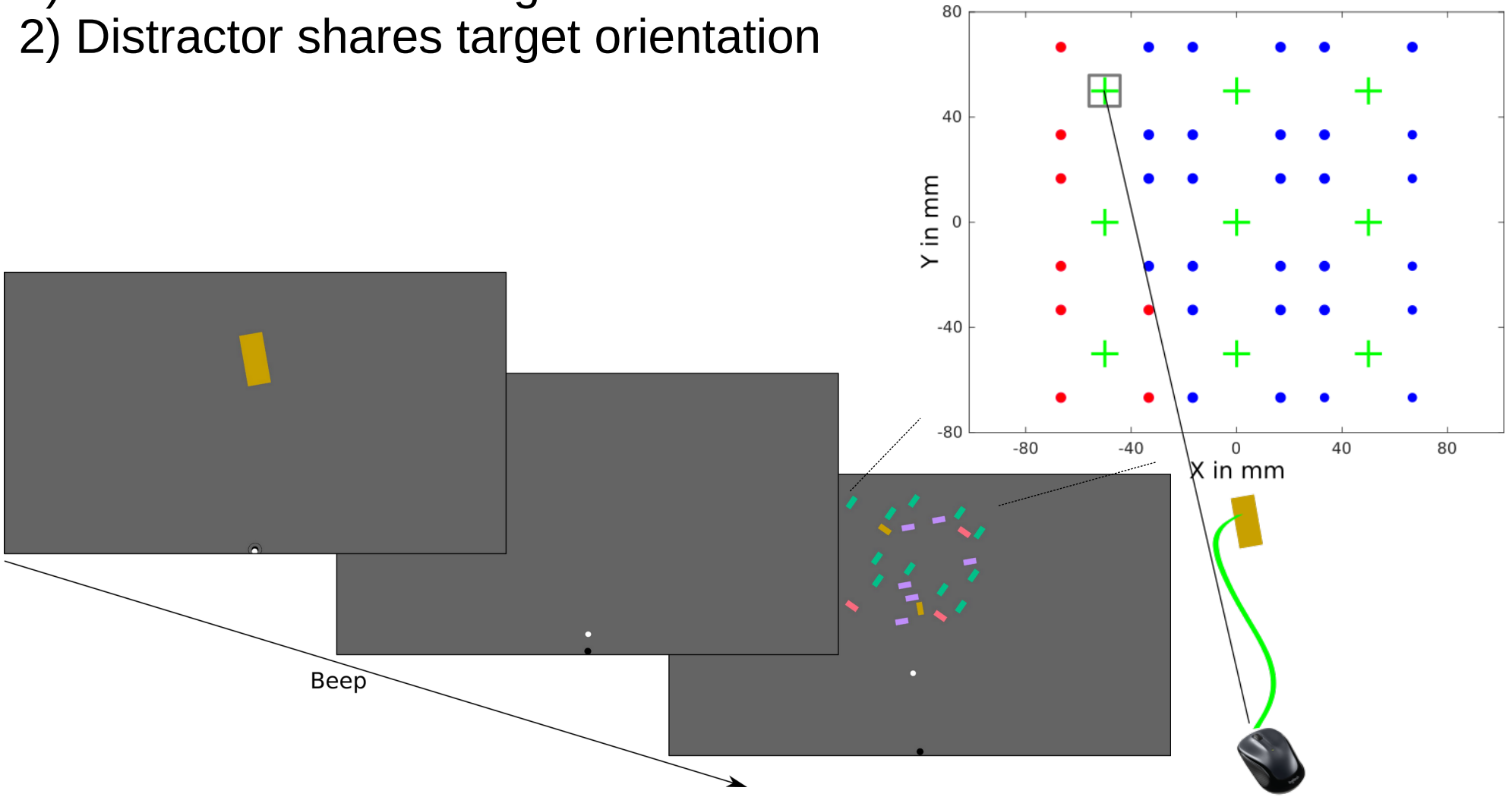


➔ If not task relevant items draw attention do they have a similar effect as a potential target?

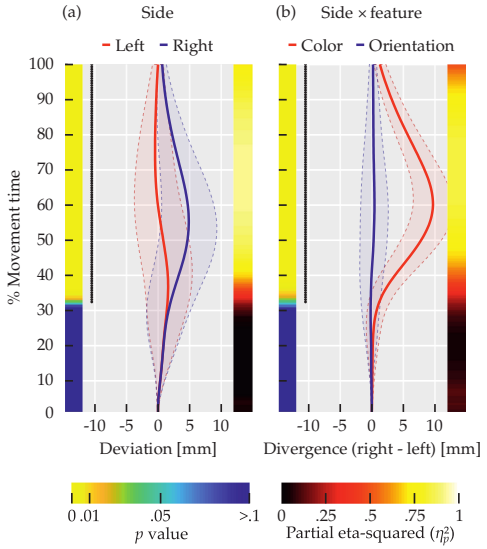
Methods I

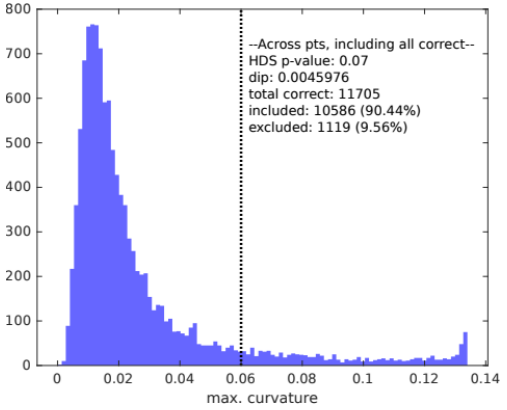
Conditions:

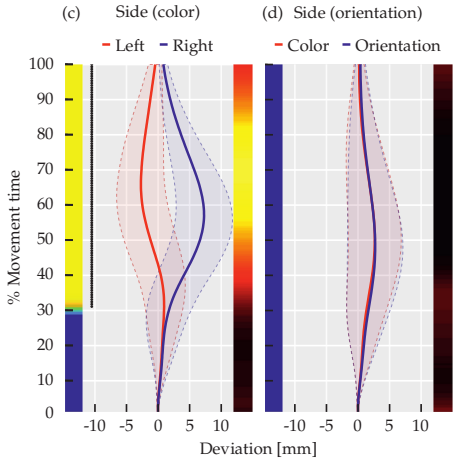
1) Distractor shares target Color
2) Distractor shares target orientation

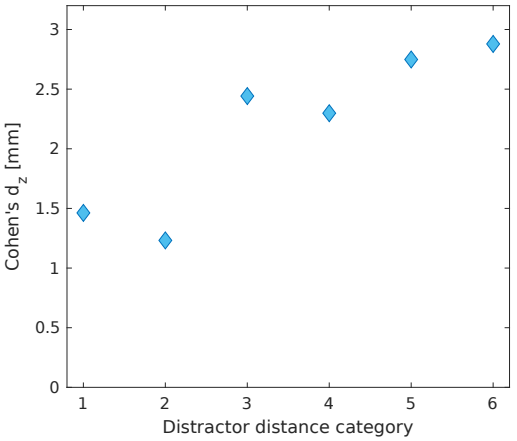


Results I


(a) Side
Left
Right
% Movement time
Deviation [mm]
(b) Side × feature
Color
Orientation
Divergence (right - left) [mm]
0 .01 .05 >.1
p value
0 .25 .5 .75 1
Partial eta-squared (η_p^2)

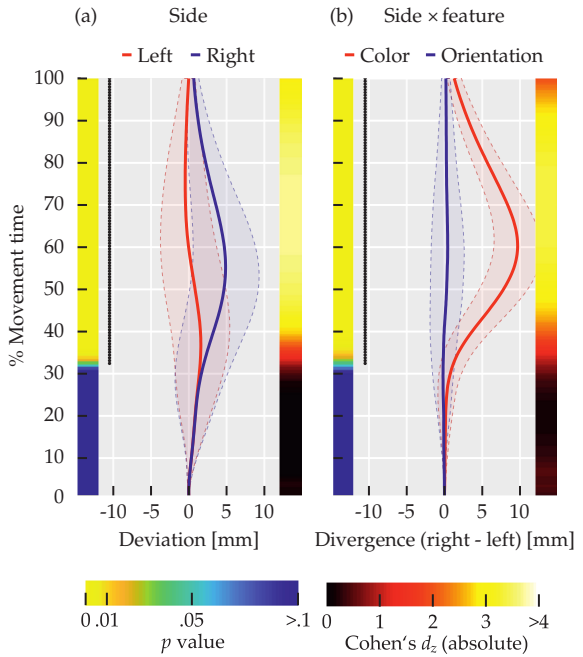

--Across pts, including all correct--
HDS p-value: 0.07
dip: 0.0045976
total correct: 11705
included: 10586 (90.44%)
excluded: 1119 (9.56%)
max. curvature


(c) Side (color)
Left
Right
% Movement time
Deviation [mm]
(d) Side (orientation)
Color
Orientation


Cohen's d_z [mm]
Distractor distance category

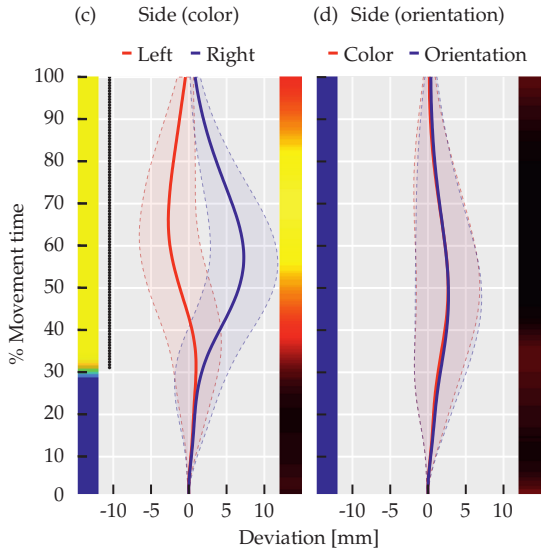
Mean trajectories

Distractor effect over all conditions



Feature Effect

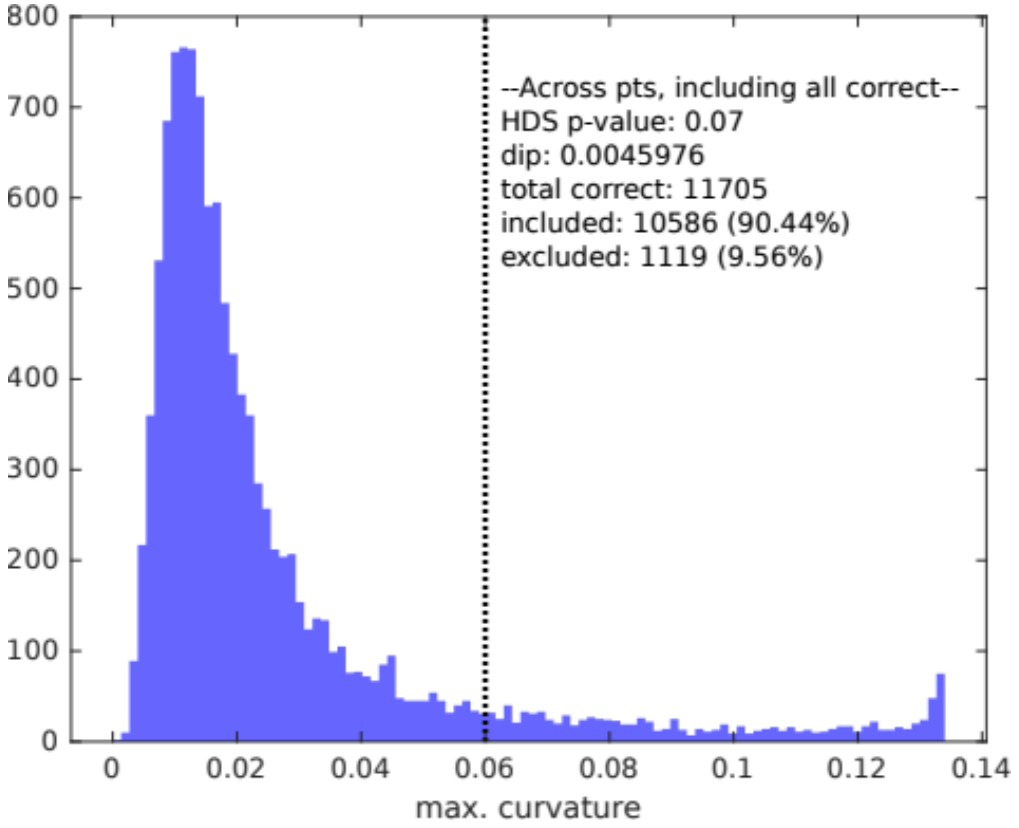
Distractor effect in color



No effect in orientation

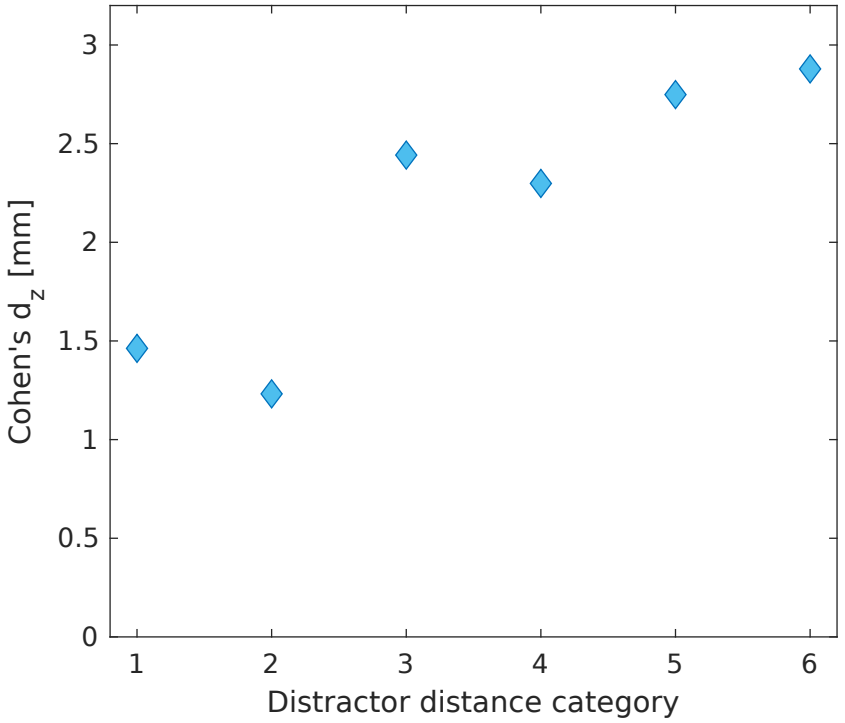
Bimodality

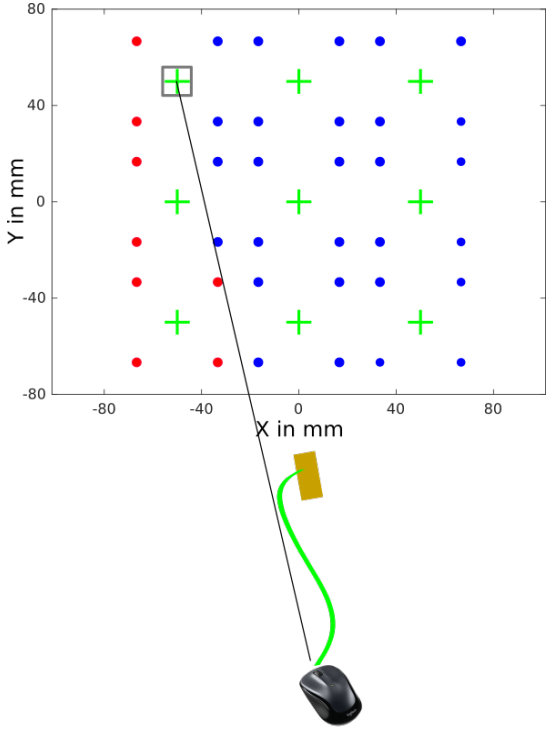
We calculated the curvature of the individual trajectories to test for bimodality



=> The trajectories belong to one population

Distractor effect





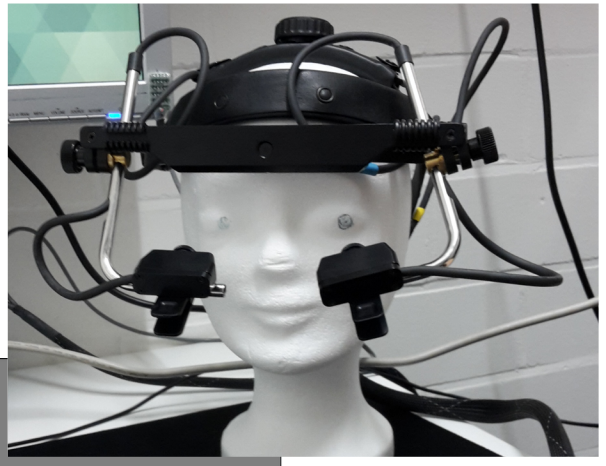
=> The distractor effect is stable over distance

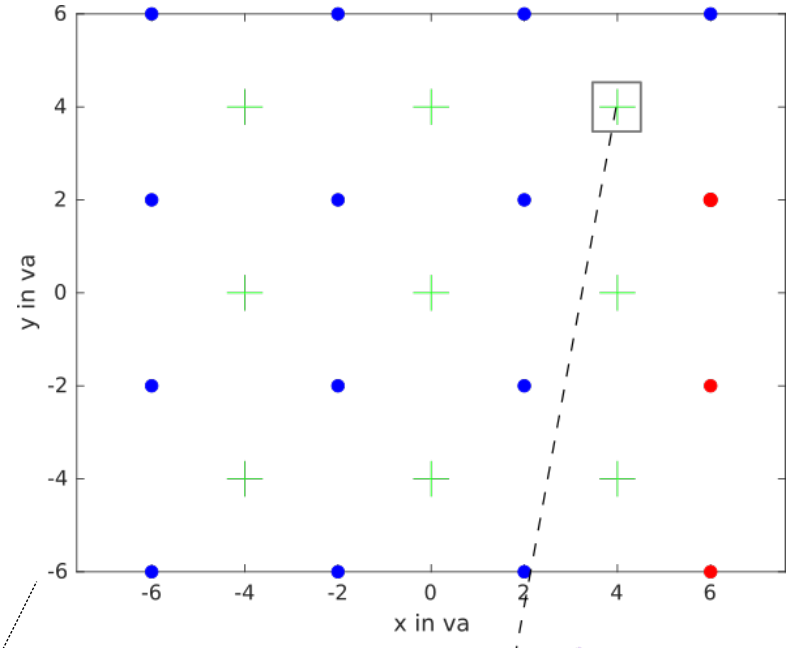
Results II

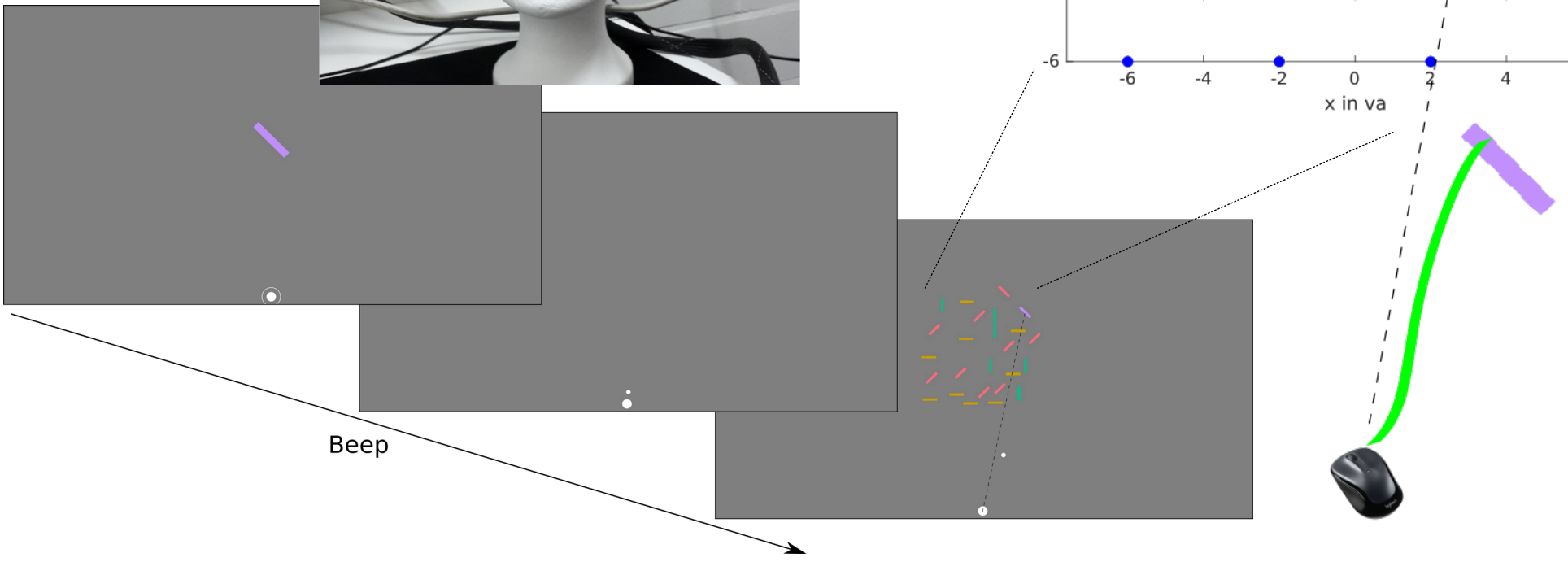
- A distractor with the same Color as the target attracts the mouse trajectory
- This attraction effect is not there for shared Orientation
- The attraction effect is independent of the distance from the target

Experiment II

Conditions:
1) Distractor shares target Color
2) Distractor shares target orientation
3) Distractor shares no target feature







Eye-movements and Attention shifts

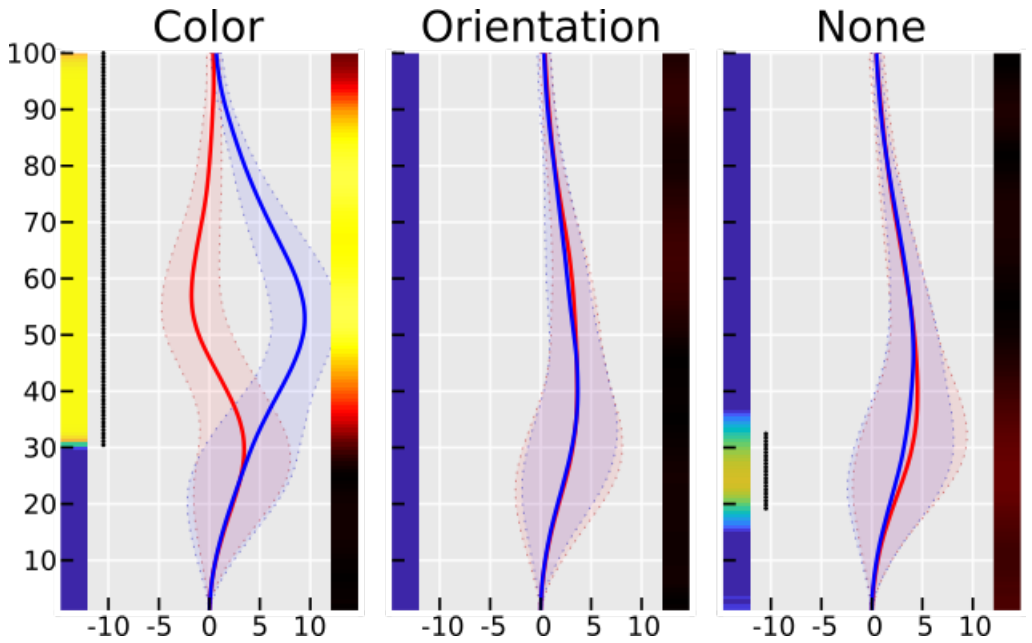
overt search

- a series of eye movements made to bring complex items onto the fovea
- Saccade is preceded by attention shift

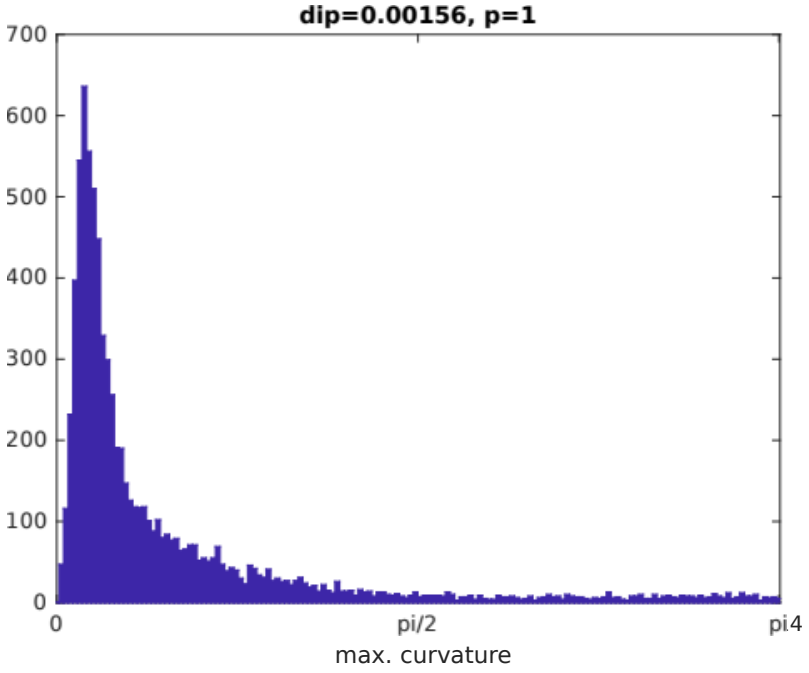
covert search

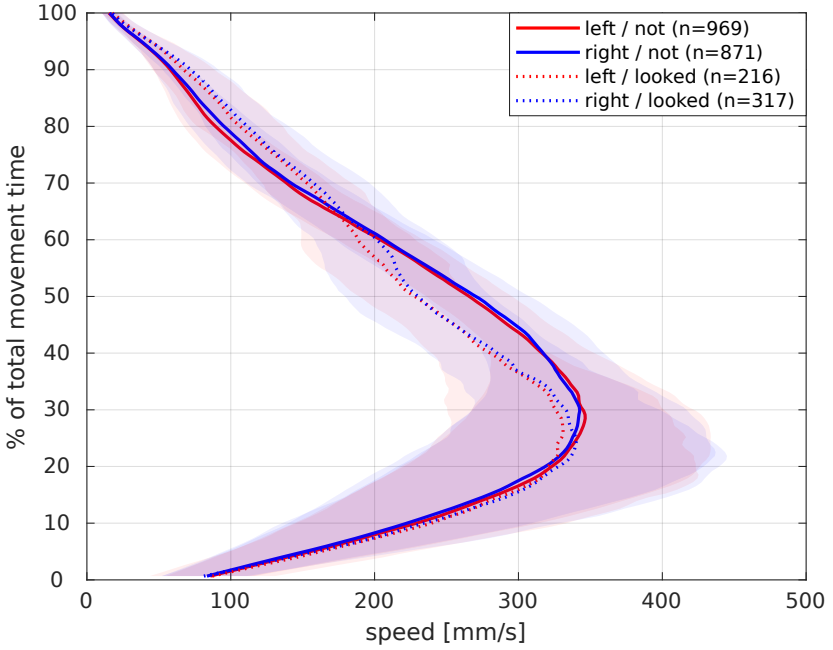
- if the items are large enough to be identified without fixation
- VS can be performed while focusing a single point
- covert attentional shifts are inferred rather than directly observed

Results II

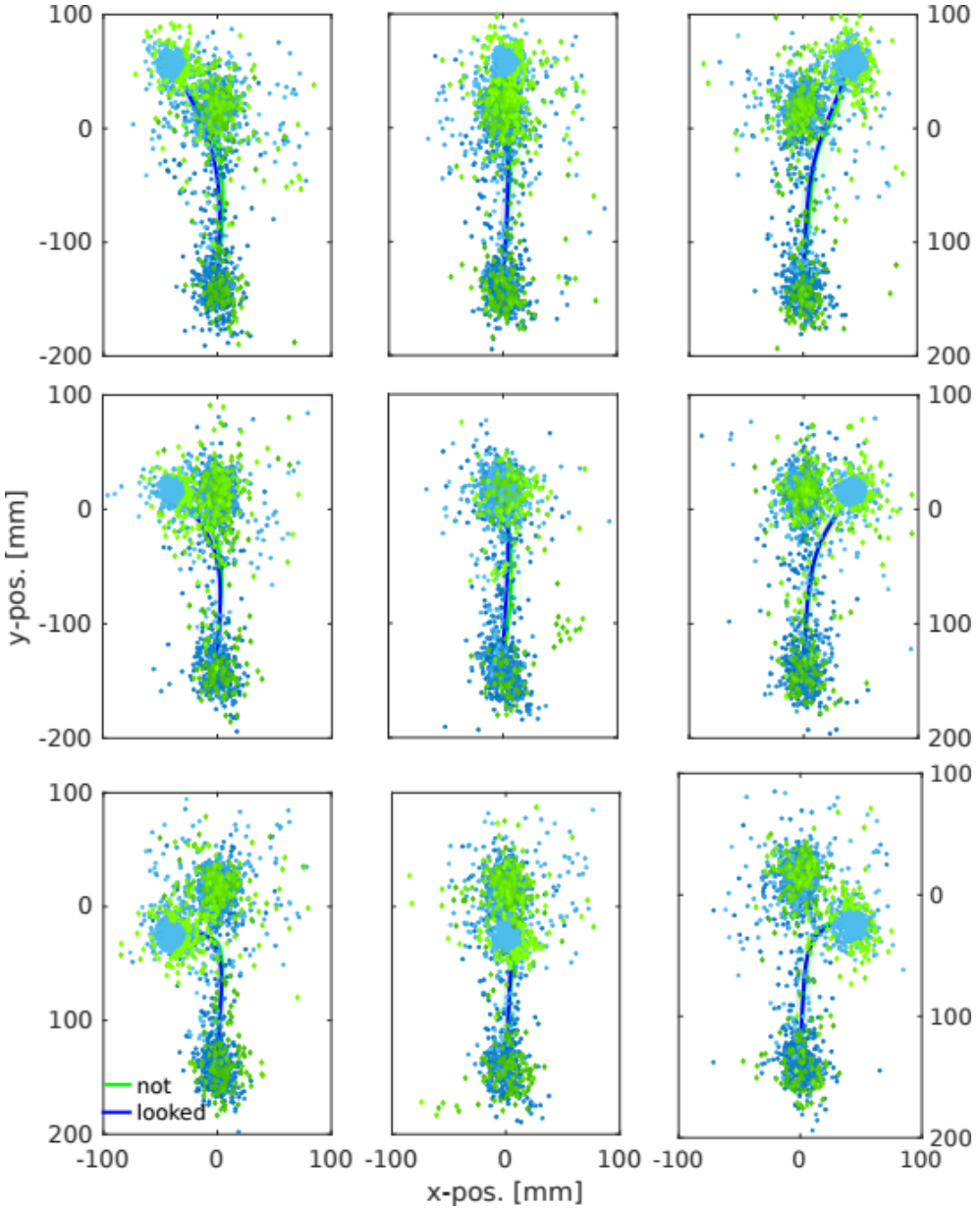

Color
Orientation
None
100
90
80
70
60
50
40
30
20
10
-10 -5 0 5 10
-10 -5 0 5 10
-10 -5 0 5 10

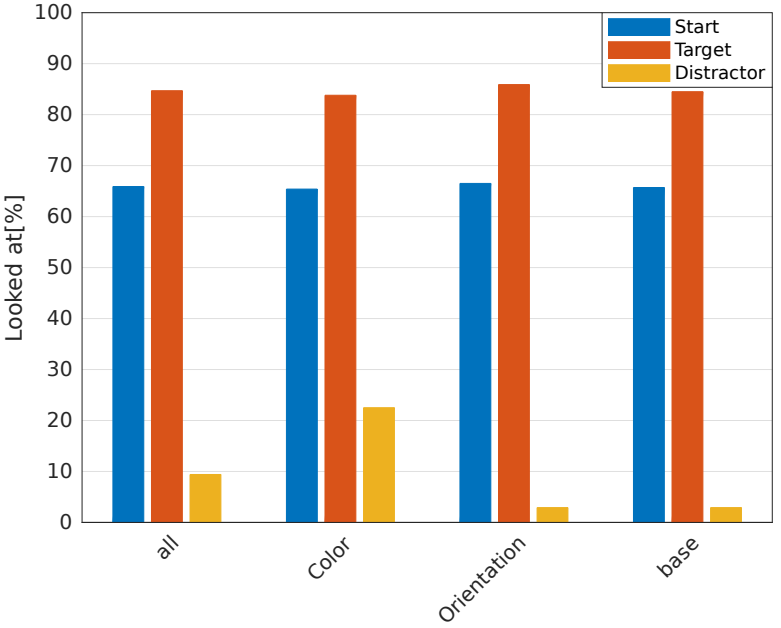
Bimodality





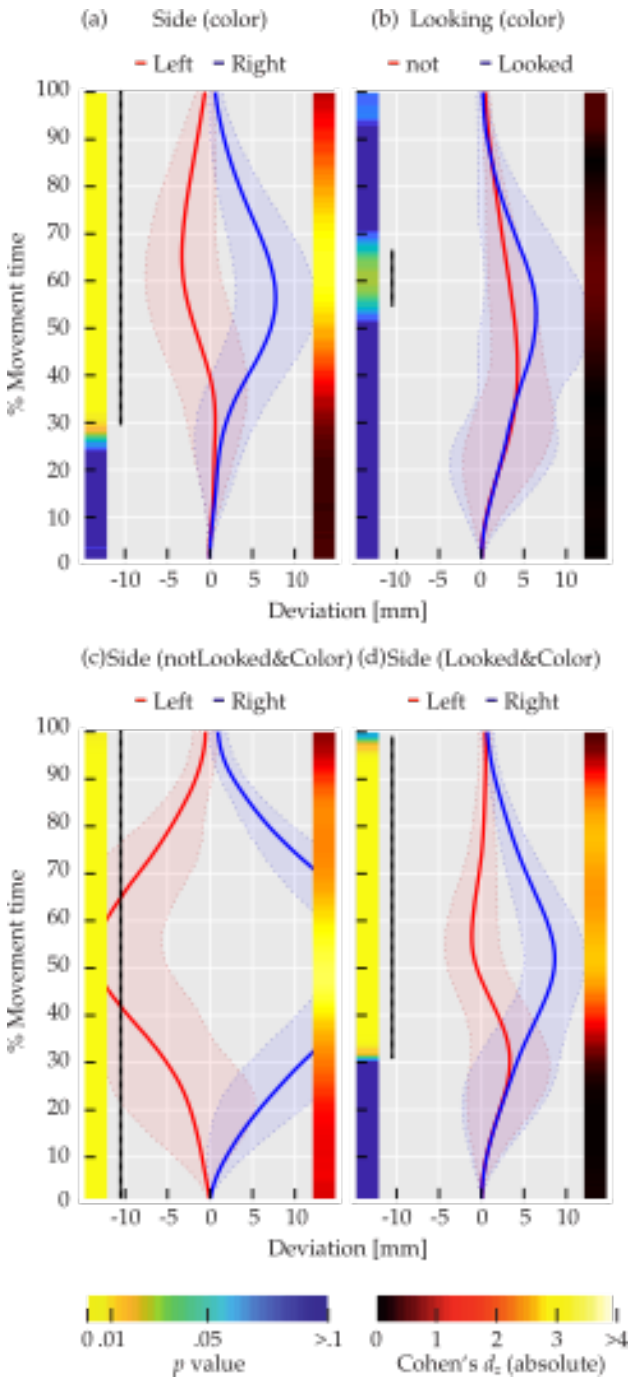
=> The trajectories also belong to one population





=> Fixations are made at points of interest – but the distractor was rarely fixated

Distractor effect in color



No Looking effect in color

Distractor effect in color & notLooked

Distractor effect in color & Looked

Conclusion

- Same-colored distractors attract mouse trajectories in conjunctive visual search
- No effect for same-Oriented distractors
  - Color dominates visual search: Orientation is only used as feature if color is not available [Alexander, R., & Zelinsky, G. (2014)]
- Covert attention shifts in visual search create deviations in human movement

➔ Not task relevant items can attract mouse trajectories in visual search depending on their features

Thank you for your attention!
Questions?