Large Pupils Predict Goal-driven Eye Movements

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Last Monday during my lecture
at the pupil colloquium

Sometimes eye movements are
predicted by saliency

Where did I leave my abstract book?

Sometimes saliency predicts
very little

Eye movements

- Eye movements are always driven by
 - Goals (or top-down influences)
 - Saliency (or bottom-up influences)
- What determines the strength of each influence?
 - Are saliency-driven eye movements the default?
 - Are goal-driven eye movements effortful?

Goals vs saliency

- Goals and saliency correlate
 - Important things are salient [1]
- To dissociate
 - Search for low-salient targets
 - So that saliency doesn't help you

Prediction*

Goal-driven eye movements

Effortful → Large pupil
Little guidance by saliency

Zoned-out eye movements

Effortless → Small pupil
Strong guidance by saliency

Negative correlation between
pupil size and the saliency of
the currently fixated location

*A prediction of sorts: We initially observed this by chance, and then retested the finding in two new datasets.

Methods

Results

Not taking into account potential confounds

Methods

Results

Results

- These results were for one fixation
 - Pupil size _{i} → Fixation saliency _{i}
- Is this relationship temporally diffuse?
 - Pupil size _{$i+1$} → Fixation saliency _{i}
 - Pupil size _{$i+2$} → Fixation saliency _{i}
 - Etc.

Results

Discussion

- Pupil size predicts goal-driven eye movements
 - Large pupils → goal driven (on task)
 - Small pupils → saliency driven (zoned out)
- Goal-driven behavior fluctuates
 - Cycles of several seconds [1,2]
- Saliency-driven eye movements are the default
 - It's what you do when you zone out
 - Goal-driven eye movements take effort

Thank you!

Laboratoire de
Psychologie
Cognitive

Thank you for your attention

Sebastiaan Mathôt

Mathôt, S., Siebold, A., Donk, M., & Vitu, F. (2015).
Large pupils predict goal-driven eye movements. *J Exp Psychol Gen*

Mathôt & Van der Stigchel (in press). New light on the mind's eye:
The pupillary light response as active vision. *Curr Dir Psychol Sci*

Get papers, slides for this talk, and much
more from <http://www.cogsci.nl/smathot>

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References

- Henderson, J. M., Brockmole, J. R., Castelhana, M. S., & Mack, M. (2007). Visual saliency does not account for eye movements during visual search in real-world scenes. In M. Fischer, W. Murray, R. Hill, & R. P. G. van Gompel (Eds.), *Eye Movements: A Window on Mind and Brain* (pp. 537–562). Amsterdam, Netherlands: Elsevier.
- Lowenstein, O., Feinberg, R., & Loewenfeld, I. E. (1963). Pupillary movements during acute and chronic fatigue: A new test for the objective evaluation of tiredness. *Investigative Ophthalmology & Visual Science*, 2(2), 138–157.
- Mathôt, S., Van der Stigchel, S. (in press). New light on the mind's eye: The pupillary light response as active vision. *Current Directions in Psychological Science*.
- Mathôt, S., Siebold, A., Donk, M., & Vitu, F. (2015a). Large pupils predict goal-driven eye movements. *Journal of Experimental Psychology: General*, 144(3), 513–521. doi:10.1037/a0039168
- Mathôt, S., Schreij, D., & Theeuwes, J. (2012). OpenSesame: An open-source, graphical experiment builder for the social sciences. *Behavior Research Methods*, 44(2), 314–324. doi:10.3758/s13428-011-0168-7
- Reimer, J., Froudarakis, E., Cadwell, C. R., Yatsenko, D., Denfield, G. H., & Tolia, A. S. (2014). Pupil fluctuations track fast switching of cortical states during quiet wakefulness. *Neuron*, 84(2), 355–362. doi:10.1016/j.neuron.2014.09.033
- Van Zoest, W., Donk, M., & Theeuwes, J. (2004). The role of stimulus-driven and goal-driven control in saccadic visual selection. *Journal of Experimental Psychology: Human Perception and Performance*, 30(4), 746–759. doi:10.1037/0096-1523.30.4.749