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Scaling of anticipatory smooth pursuit eye movements with target speed probability

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Background

Anticipatory smooth pursuit permits tracking of expected target trajectories with little delay. It can be a mirror of cognitive expectations, but It is still unclear how these expectations are built. Pursuit anticipation scales with several target parameters in an adaptive way [1]. This is compatible, for instance, with a switch between expectation states after one or several wrong guesses [2]. Alternatively, the underlying mechanism could rely on a global subjective probability estimation.

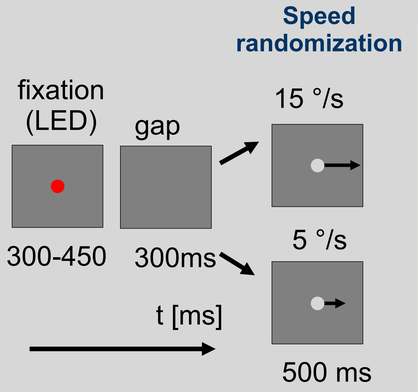
Goals – clarify the nature of the expectations that drive anticipatory pursuit

- by examining effects of velocity and direction randomization across blocks of different probability
- by looking at trial history effects

Pursuit task

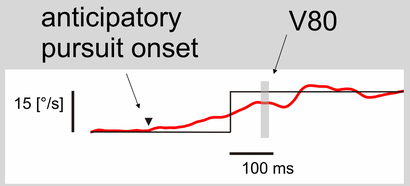
3 human subjects participated in two experiments. Eye movements were recorded with a scleral search coil.

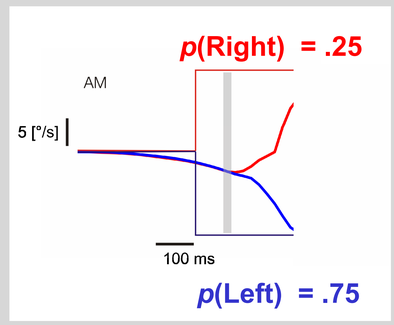
Each probability block comprised 250-500 trials with two possible values of target speed (Exp. 1) or direction (Exp. 2). The probability *p* of the highest speed (or of the right direction) to be presented was varied from 0 to 100% across blocks.



Probability bias ***P* (V=15) ={0 -100%}** ***P* (Right) = {0 -100%}**

Data analysis

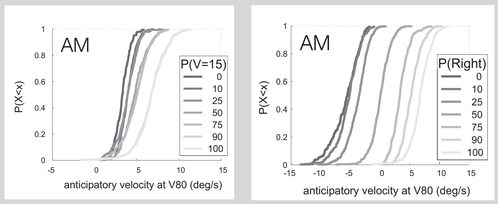




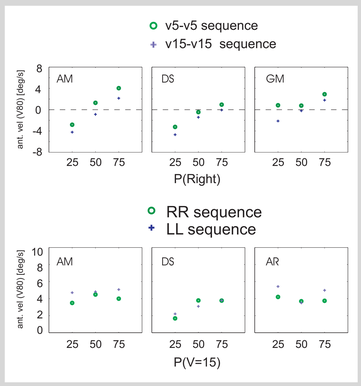
Distribution

Anticipatory velocity (V80) has a unimodal distribution which shifts with *p* both for speed and direction randomization

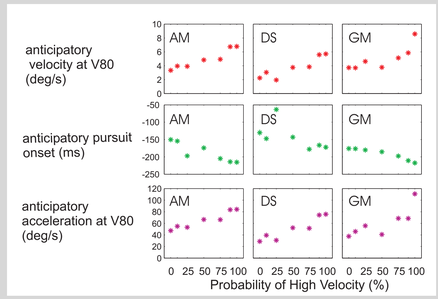
Speed rand. **Direction rand.**



Sequence effects



Scaling with block probability

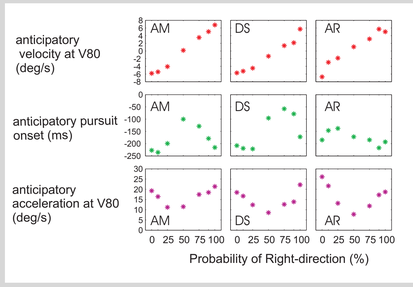


Speed rand.

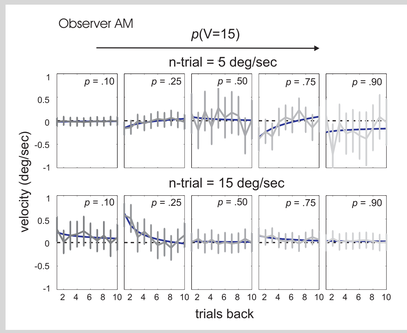
Anticipatory velocity (V80), latency and mean anticipatory acceleration scale with probability bias

Direction rand.

Anticipatory velocity (V80) scales linearly with probability bias. Anticipatory pursuit onset and mean acceleration scale with absolute anticipatory velocity.



Trial-history effects



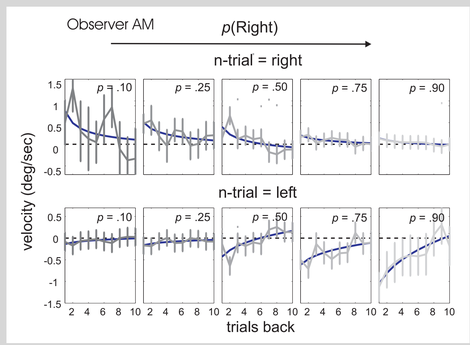
Speed rand.

Effects of the nth previous trial on the current trial, for a 5 (upper panels) or 15 deg/sec target motion.
Error-bars = C.I.

Effects increase with scarcity of stimulus

Direction rand.

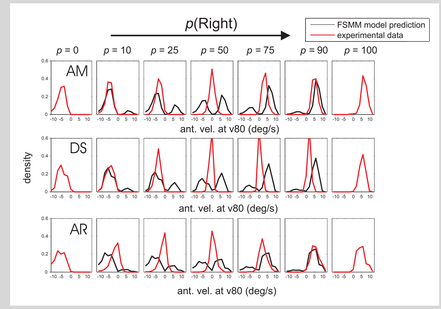
Effect of nth previous trial on current trial when it was a leftward or rightward target.
Error-bars = C.I.



Disagreement with previous models

Markov two-states model [2]:

Anticipatory pursuit may reflect alternation between two mutually exclusive states of expectation (high vs. low velocity or left vs. rightward). This model predicts a bimodal distribution of anticipatory pursuit for intermediate values of *p* (black curve)



Our experimental results (red curves) disagree with this prediction: an alternative model could better predict the shift of the unimodal distribution with *p* (e.g. a continuous *accumulation-of-evidence* model)

Conclusion

- Scaling of anticipatory speed with probability: favoring low speeds for speed randomization, nearly linear for direction randomization
- Large effects of the last 2-4 trials. Two wrong expectations are not enough to turn off anticipations in biased blocks.
- Anticipation may better be explained by a continuous *accumulation-of-evidence* model
- **Coming soon:** quantitative predictions

References

[1] Heinen, S. J., Badler, J. B., & Ting, W. (2005). *J Vis, 5*(6), 493-503.
[2] Kowler, E., Martins, A. J., & Pavel, M. (1984). *Vis Res, 24*(3), 197-210.

http://www.unige.ch/fapse/cognition/souto