Biological Motion from Second-order and Motion energy cues

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INTRODUCTION

Point-light walkers show that we perceive complex biological motion from a handful of moving dots. Real-world signals vary—luminance-defined, contrast-defined, or carrier-based—and peripheral vision may treat them differently.

Luminance Defined (FO)
Contrast Defined (SO)
Motion Energy (ME)

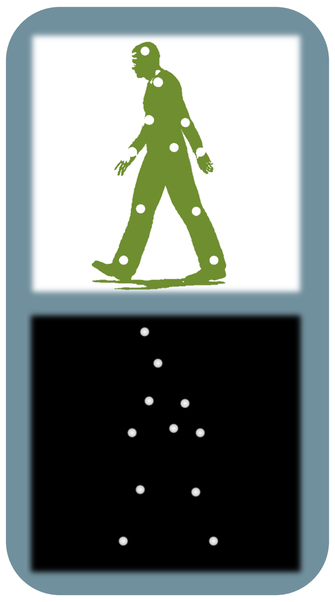


Image 1: Point Light Walker

METHODS

1. Ambiguity Calibration

- 3-up/1-down adaptive run at 10 ° eccentricity.
- Step size: ±0.1 “Squish” units; 75 – 85 % correct.
- 5 reversals in the last 20 trials; final 10 reversals gave each subject’s individual ambiguity level.

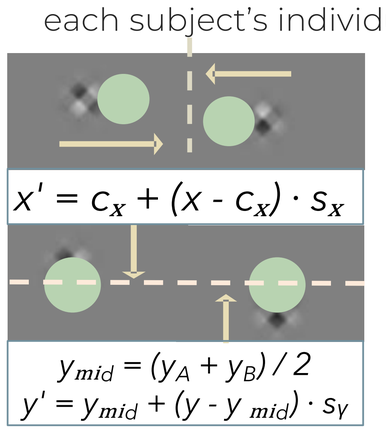


Image 2: Ambiguity X and Y calibration

2. Main Experiment

- Stimuli:
  - FO = first-order (luminance dots)
  - SO = second-order (Contrast defined)
  - ME = motion-energy
- Eccentricities: 0°, 10°, 20 °;
- Design: 3 x 3 x 2 within-subject;
  - 144 trials.
- Task: 2-AFC “Left or Right?” confidence rating (1-3)

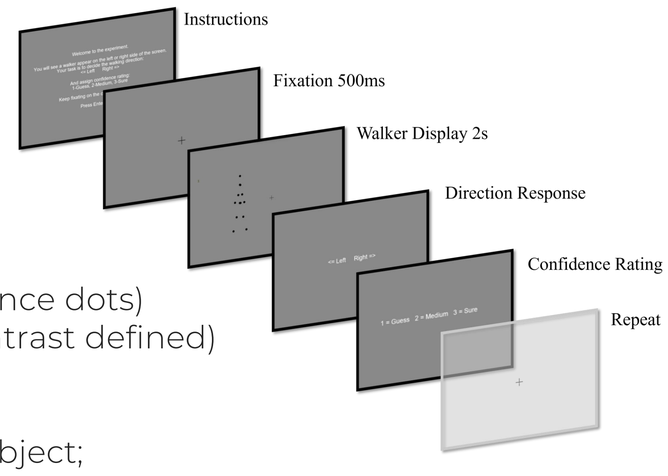
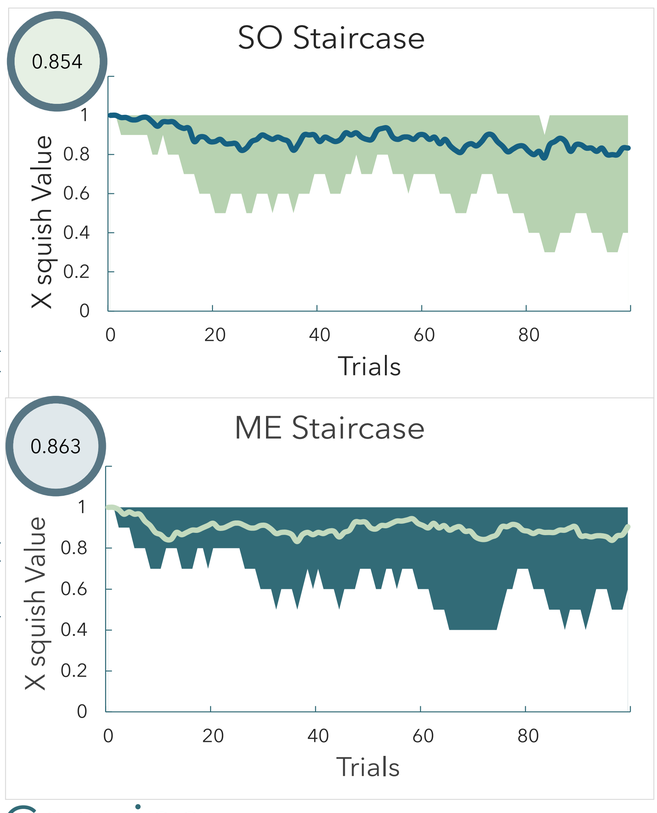


Image 3: Experiment Design

RESULTS



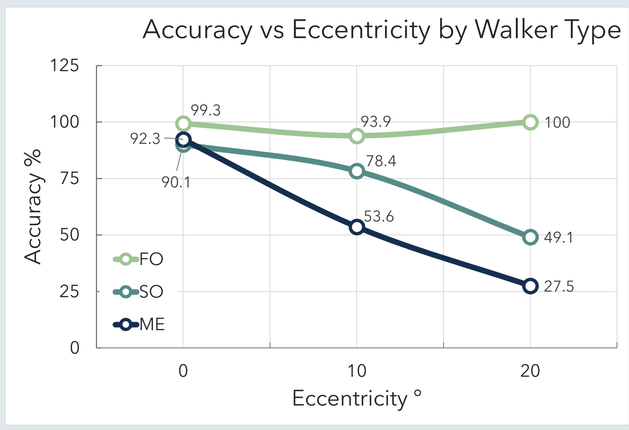
Graph1: (a) SO staircase (b) ME staircase

- Group **mean accuracy** = 79 %.
- **Mean threshold** for SO = 0.854, ME = 0.863
- **Stability**: SD of the final 10 reversals = 0.04 (group average).
- **Reversals** achieved: Mean = 18 (range 16–21);

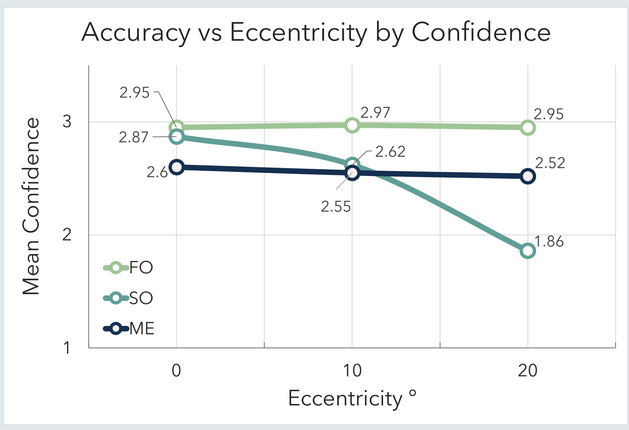
Individual thresholds were used unaltered in the main experiment

First Order Motion (**FO**) showed the most robust performance. While Second order (**SO**) and Motion Energy (**ME**) drop in accuracy.

- Both eccentricity and motion type effect was significant. However, only SO motion decreased in confidence while ME stayed robust coupled with low accuracy.



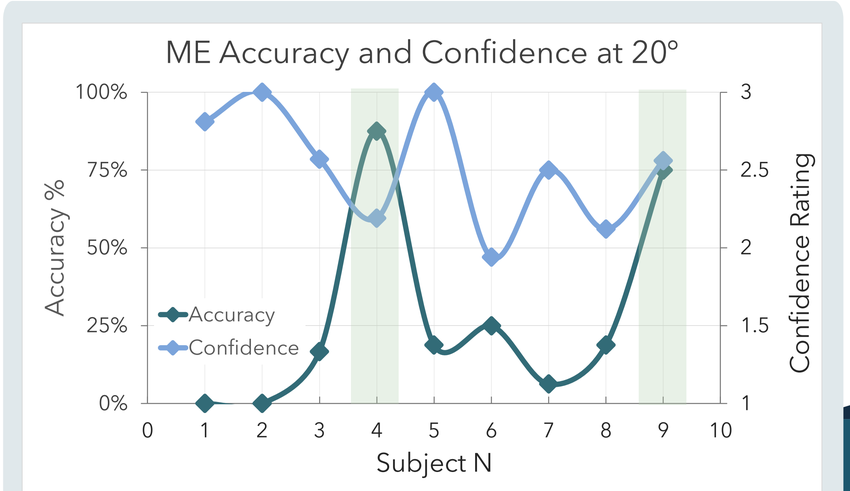
Graph 2.a: Mean Accuracy vs eccentricity by 3 different walker types.



Graph 2.b: Mean Accuracy Confidence vs eccentricity by 3 different walker types.

Genuine Misperception?

If we look at ME motion alone, it can be seen that accuracy and confidence are somewhat counteracting with each other. Almost all subjects showed low accuracy except for N = 4 and 9.



Graph 3: Accuracy and Confidence for ME by each subject

Walker type	Comparison	*t*	*p*
FO	0° vs 10°	1.179	0.544
	0° vs 20°	-1.000	0.347
	10° vs 20°	-1.386	0.61
SO	0° vs 10°	2.04	0.076
	0° vs 20°	5.617	0.001*
	10° vs 20°	2.781	0.05*
ME	0° vs 10°	4.523	0.008*
	0° vs 20°	6.721	0.001*
	10° vs 20°	4.462	0.012*

Comparison	*t*	*p*
FO vs SO	7.224	0.00018*
FO vs ME	10.972	0.00001*
SO vs ME	4.446	0.00215*

Comparison	*t*	*p*
0° vs 10°	7.265	0.00026*
0° vs 20°	7.198	0.00019 *
10° vs 20°	3.477	0.00835*

Table 1: (a) Significance on eccentricity by motion type and by (a) motion type and (c) eccentricity

N Left-out	*t*	p
1	-1.6	0.1537
2	-1.6	0.1537
3	-1.769	0.1202
4	-3.396	0.0115**
5	-1.713	0.1304
6	-1.769	0.1202
7	-1.629	0.1474
8	-1.713	0.1304
9	-2.749	0.0286**

Table 2: Leave-one-out Significance test on ME

Although
the accuracy drops below 50% at 27.5%, indicating a potential opposite responding, it is not significantly different from 50% guessing.

However
leaving one of the subjects out and calculating significance shows that without 1 of 2 subjects that scored highest accuracy gives a significant difference.

Discussion & Conclusion

Peripheral accuracy collapsed only when walkers relied on contrast apertures or carrier motion, not on luminance dots. Second-order and motion-energy cues require intact low-level motion energy, which weakens with eccentricity.

First-order PLWs remain robust across the visual field, but second-order and motion-energy walkers fail beyond 10 °, implying that form-based mechanisms—not local motion energy—underpin peripheral biological-motion perception.

Limitations & future work:

- *With only 9 subjects, it was unclear whether there is a misperception*
- *Calibration Point starting from 1.00 lead to some ceilings.*
- *Increase in total number of trials would give more precise results*

Reference:

- Johansson, G. (1973). Visual perception of biological motion. *Perception & Psychophysics, 14*(2), 201–211.
- Blake, R., & Shiffrar, M. (2007). Perception of human motion. *Annual Review of Psychology, 58*, 47–73.
- Gurnsey, R., Poirier, F., & Denmark, T. (2010). Perceiving biological motion from second-order cues. *Vision Research, 50*, 2201–2210.
- Aaen-Stockdale, C., & Thompson, P. (2008). Second-order motion is re-coded into first-order form before direction discrimination. *Journal of Vision, 8*(2), 1–13.