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Does linear perspective resolve depth ambiguity in biological motion displays?

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INTRODUCTION

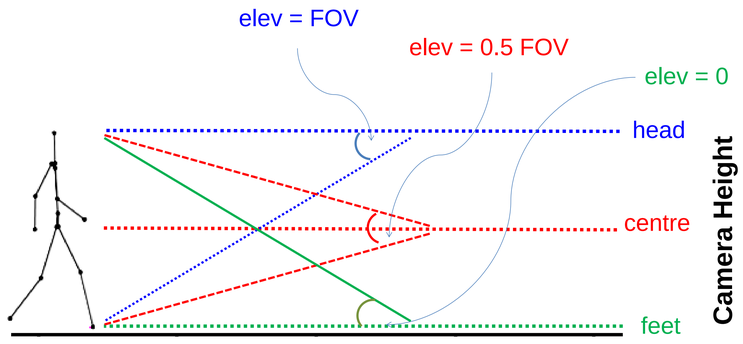


Fig. 1: Relation between camera height, FOV, and camera elevation

Point-light walkers (PLW) and stick figures rendered orthographically and deprived of any other depth cues can potentially generate two equally valid percepts. For example, a fronto-parallel projection can be seen as either facing the viewer or facing away from the viewer.

However, most observers tend to see the walker Facing the Viewer (FTV) (Vanrie et al., 2004).

Rendering the figures with a projective camera has the potential to resolve depth-ambiguity. Decreasing distance between the rendering camera and the PLW figure gradually reveals its real orientation and can be used to counteract the FTV bias (Vanrie et al., 2004; Schouten et al., 2010; Schouten et al., 2013).

Does that mean that observers can use linear perspective to retrieve information about depth in amorphous, dynamically deforming object such as a human body in motion?

It would be surprising if they could:
- The human body does not contain parallel lines, right angles or other simple structures to constrain the interpretation of a 2D projection.
- Humans come in various shapes. Factoring out invariants that remain intact under perspective projection, and are insensitive to natural variations in body shape would be challenging.

Here, we test an alternative hypothesis:
- The effect of camera distance is not directly due to perspective (rather than orthographic) projection.
- Rather, observers focus on the feet and interpret any deviation from a fronto-parallel projection to result from a camera elevated above the floor, rather than one that looks at the feet from below.
- If the approaching camera has some height above the floor, the elevation angle of the camera with respect to the feet increases as the camera approaches. The higher the camera, the more changes camera elevation.

It has been shown before in other contexts that:
- observers are attracted to the motion of the feet as compared to other body parts (Troje & Westhoff, 2006)
- observers have a preference to view walkers (as well as other objects) from above (Troje & McAdam, 2010).

METHOD

Design & Procedure

"Is the figure coming towards you, or going away from you?"

- Modified version of Schouten and Verfaillie's (2010) technique
- Varying field of view angle, FOV (= varying camera distance)
- Interleaved staircases to measure 75% FTV and 25% FTV thresholds
- Camera adopts three different heights above ground (Fig. 1):
  - **head** – Camera at walker height
  - **centre** – Camera at mid-walker height
  - **feet** – Camera at floor level
- 40 trials per staircase, 240 trials total (3*2*40 trials)

Predictions

- If linear perspective disambiguates walker direction camera height should have no effect.
- If elevation of the camera with respect to the feet matters, we would expect the effects of camera distance to increase with camera height.

Participants

- Ten participants recruited on Queen's University Campus
- Age: *M* = 24.9 years old (*SD* = 2.8)
- Six females and four males.

Stimuli

- Dynamic stick figure walkers (Troje, 2002)
- White against black background
- Frontal view
- Size: 3.2 deg
- Presentation time: 2 s

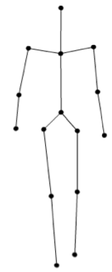
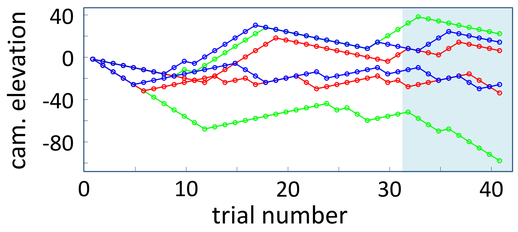


Fig. 2: The six interleaved weighted staircases from a typical participant. The last 10 trials were averaged and used as a measure.



RESULTS

Threshold level	Camera height	Field of view [deg]	(SEM)	Cam. elevation [deg]	(SEM)
75 %	head	2.8	(1.9)	2.8	(1.9)
	centre	3.7	(1.9)	1.8	(0.9)
	feet	2.8	(11.3)	0	
25 %	head	-10.4	(1.7)	-10.4	(1.7)
	centre	-17.1	(2.6)	-8.6	(1.3)
	feet	-87.4	(11.6)	0	

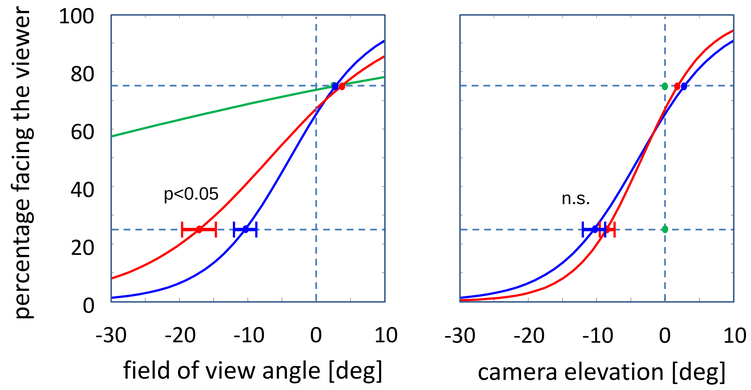


Fig 3: Thresholds expressed as (a) FOV, and (b) camera elevation. Data are fitted with a logistic function for visualization purposes.

Summary

- 75% threshold approximates infinite distance (orthographic projection, FOV=0 deg) → replicates Vanrie & Verfaille's (2004) observation.
- 25% thresholds depend strongly on camera height. Paired T-test centre vs. head, n=10: p = 0.02.
- If camera is at feet level, no stable 25% threshold is reached and massive variation is observed at 75% threshold.
- Considering camera elevation explains the apparent difference between the head and centre conditions.
- It also explains failure of reaching stable thresholds in the feet condition

CONCLUSION

No! Observers are not able to efficiently exploit linear perspective to resolve depth-ambiguity in a stick figure.

The effect of camera distance is rather due to camera elevation with respect to the feet in combination with a viewing-from-above bias.

REFERENCES

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