Interactions between viewing from above and global convexity priors in the interpretation of depth ambiguous shape-from-contour drawings

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Introduction

Observers usually prefer the 'view from above' (VFA) interpretation of depth ambiguous stimuli that could have been rendered with a viewpoint from above or below (Troje, 2010).

We asked the following two questions:

1. Does inducing an observer to look up or down in the real world bias the viewpoint adopted when interpreting depth ambiguous stimuli?
2. Does the visual system employ a prior understanding of physics when choosing a perceptual viewpoint?

Experiment 1: Design

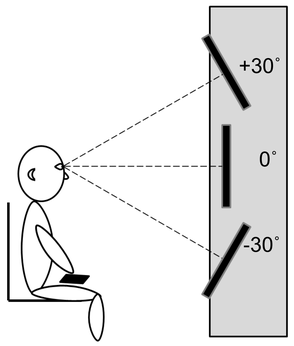

Figure 1. Apparatus in Experiment 1. Screens were positioned at +30˚, 0˚, and -30˚ elevation angles and were tilted towards the observer.

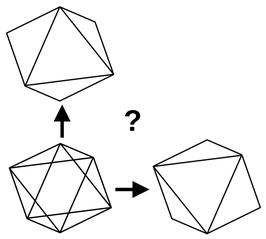

Figure 2. Rotating depth ambiguous stimuli can be perceived as if viewed from above or below. Stimuli were rendered with a camera at 30˚.

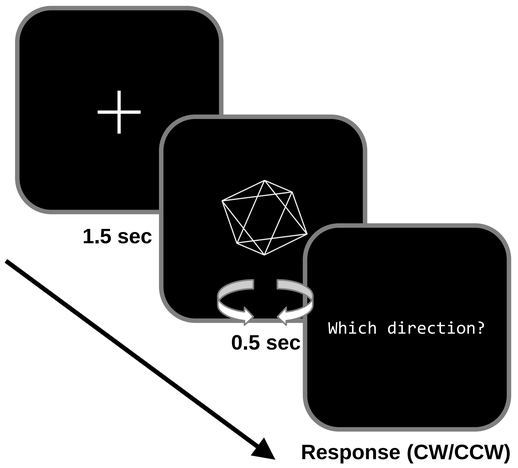

Figure 3. Procedure in Experiment 1.

Screens were cued by a fixation cross. Participants observed the rotating stimulus, then responded clockwise or counterclockwise (CW/CCW).

6 practice trials followed by 120 test trials took place (azimuth angle was randomized each trial).

Experiment 1: Results & Discussion

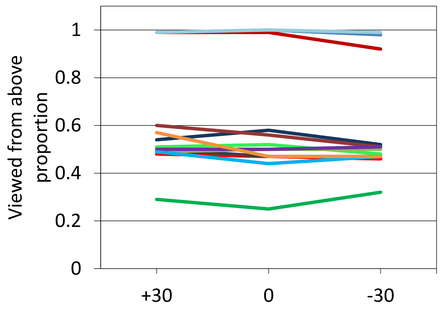

Figure 4. Proportion of trials in which stimuli were VFA for each of the three screens (+30, 0, and -30 degrees of elevation) for each subject (N = 13).

Repeated measures ANOVA: $F(2, 24) = 3.45$, $p = 0.048$, partial eta^2 = 0.22.

- Stimuli on the lower screen were seen slightly *less* VFA than other screens (Figure 4). We concluded that **VFA bias is not influenced by the real-world line of sight angle of the observer.**
- Surprisingly, stimuli were seen VFA in only 60% of cases–40% less often than the Necker cube (Troje, 2010).

This seemed to show a second prior at work: the structural stability of the object might be taken into account when choosing a perceptual viewpoint for ambiguous stimuli. We developed and tested this idea in Experiment 2.

Experiment 2: Design

Does stimulus support-base stability influence VFA bias?

- Diamond = unstable, Necker cube = stable

Or, does the number of ground-aligned planes influence object perception?

- Diamond = one plane, Necker cube = two planes

Procedure was the same as Experiment 1 apart from the following: 624 trials (104 x 6), blocked by stimulus; one screen (0˚ elevation, Figure 5), 27 new subjects.

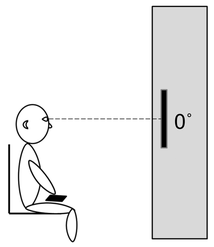

Figure 5. Experiment 2 apparatus.

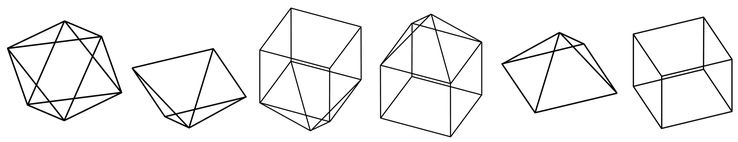

Figure 6. Stimuli in Experiment 2 differed in stability and number of horizontal planes.

Experiment 2: Results & Discussion

- 'Stable base' stimuli were seen from above more than other stimuli (Figure 6, red bars).
- One 'unstable' condition was nearly exclusively VFA (Figure 6: condition 3), although less-so than the Necker cube (paired t-test, p = 0.046).
- **Neither support base stability nor the number of ground-aligned planes appear to be the critical factor.**

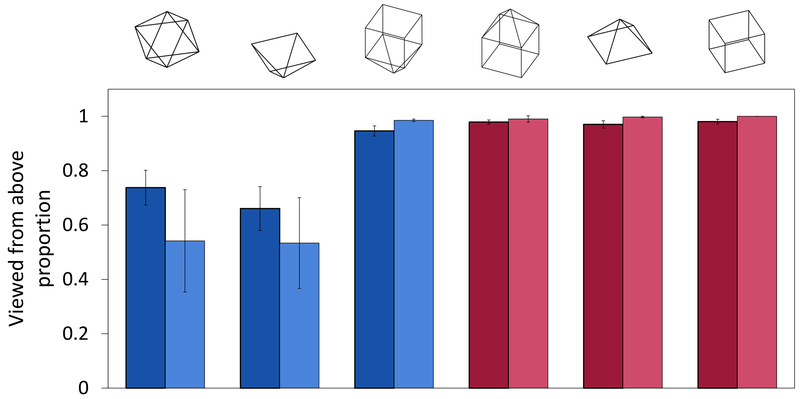

Figure 6. Darker bars show proportion of stimuli VFA in each condition. Paler bars show proportion VFA when that stimulus was seen in the first block of trials. Blue and red bars indicate stimuli with unstable and stable support bases, respectively. Error bars are SEMs.

Stable vs. unstable contrast: $F(1, 15) = 24.08$, $p < 0.001$, partial eta^2 = 0.62

Results could be explained by interaction of VFA and convexity priors (Gregory, 1970). VFA bias is strong for cubes; for other stimuli, points are seen oriented towards the observer.

Why are cubes more prone to VFA?

- Cubes could be more 'thing-like'; object perception is difficult for other stimuli
- Moderate VFA bias for cubes reinforced over time

To assess if there was reinforcement of priors in our data, we asked: how often were stimuli in the first block VFA, given that the first block was either a 'stable' or 'unstable' base condition?

- Generally lower VFA responses when 'unstable base' seen first (Figure 6, paler bars), apart from the cube stimulus.
- This explains the difference between diamond stimuli in Experiment 1 (only 'diamonds'; 60% VFA) and 2 (multiple stimuli; 74% VFA for 'diamonds').

Conclusion

The VFA bias is robust to real-world viewing elevation angle of the observer.

Overall, the data reflect a possible interaction of priors with varying strengths: VFA, convexity, and support-base stability.

We also found evidence for reinforcement of priors despite providing no feedback. This mechanism could explain the VFA dominance for Necker cube type stimuli.

Further research could determine the strength of each prior by use stimuli that isolate support base stability from convexity.

References

Gregory, R. L. (1970). The Intelligent Eye.
Troje, N. F. (2010). Poster presented at Vision Science Society meeting, Naples: FL.
Weech, S., McAdam, M., Kenny, S., & Troje, N. F. (2014). What causes the facing-the-viewer bias in biological motion? *Journal of Vision, 14*(12): 10.

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