

SUPPLEMENTARY MATERIALS FOR: DOES OPTIC FLOW PARSING DEPEND ON PRIOR ESTIMATION OF HEADING?

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FOLLOW UP EXPERIMENT

Rationale

It is possible that observers did not follow our instructions and that they made large voluntary or involuntary eye movements which could have explained the perceived probe trajectory (although we have no reason to expect that they did not follow instructions). To provide further evidence that eye movements were not the explanation for our results we have conducted a follow up study in which eye position was recorded.

Methods

Five observers took part in the follow up study. All observers were naïve to the purpose of the experiment and worked or studied in the School of Psychological Sciences, University of Manchester. All methods were similar to those of experiment 1 in the main document except that we also measured eye position. Eye movements were recorded using an Eyelink 1000 eye tracker (SR Research), with samples recorded at 1000 Hz. The eye tracker was calibrated prior to data collection using a 3 by 3 array of points at known

locations on the screen. Pre-processing of eye-movement data was similar to that undertaken in Champion & Freeman (2010). Briefly, using bespoke software written in MatLab, Eye-position data were low-pass filtered and a time derivative was taken. Any saccades occurring over the 2s trial were detected using a velocity threshold of 40 deg/s and these trials were discarded. Fixation accuracy was assessed by calculating the mean deviation from fixation in both the horizontal and vertical directions over the 2s trial for each observer in each of the 6 (field x probe position) conditions.

Results

In figure S1A we present behavioural data in a similar format to those in figure 8 of the main document. Note that the data in these two experiments are very similar with a large relative tilt across all field conditions when the probe was on the right hand side of the field but a significantly reduced effect when the probe was on the left side.

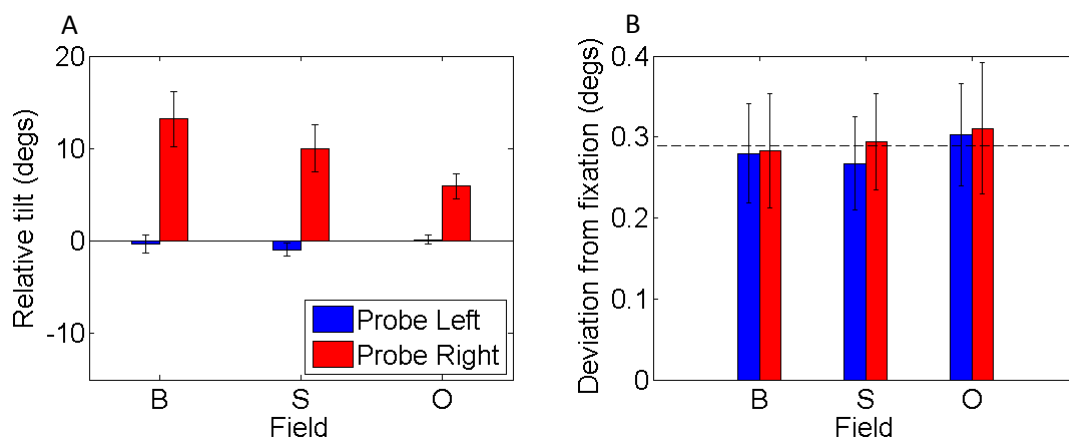


Figure S1: A. Behavioural data from follow up experiment in which eye movements were recorded.

Positive relative tilts correspond to an anti-clockwise rotation. B. Eye movement data in the form of mean deviations from fixation over observers and trials. The labels for the Field condition are “B” for Both, “S” for Same and “O” for Opposite. Error bars represent ± 1 SE.

In figure S1B we present the associated eye movement data in the form of mean displacement from fixation in the three field conditions and the two probe position conditions. First note that the mean deviation from fixation observed in all conditions is relatively small - around 0.3 degrees

(18 arcmin) or 10% of the distance to the probe from fixation. The deviations are also similar in magnitude across all flow field and probe position conditions. In figure S2 we present the deviations from fixation broken down into horizontal and vertical components. Once again there appears to be little difference between the deviations in the flow field and probe conditions but there may be some evidence for greater deviation in the vertical direction relative to the horizontal direction. However, a 3 factor (probe position x flow field structure x direction of deviation) repeated measures ANOVA revealed no main effects of or interactions between the factors (see table S1).

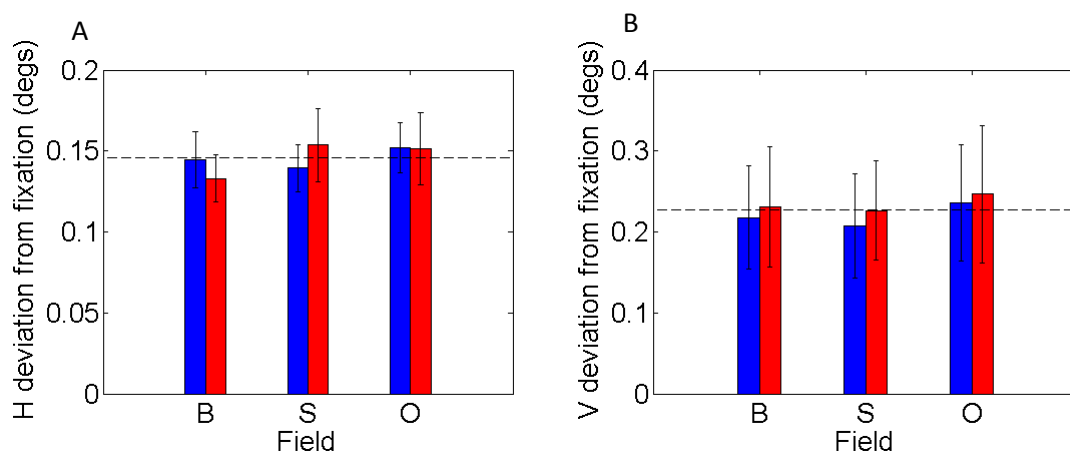


Figure S2: Horizontal (A) and vertical (B) components of deviation from fixation (i.e. the combined deviation as shown in figure S1B split into horizontal and vertical components).

Source	F	P
Deviation Direction (D)	F(1, 4) = 1.9	$p = 0.24$
Field (F)	F(2, 8) = 0.8	$p = 0.46$
Probe Position (P)	F(1, 4) = 0.1	$p = 0.76$
D x F	F(2, 8) = 0.2	$p = 0.80$
D x P	F(1, 4) = 2.7	$p = 0.18$
F x P	F(2, 8) = 1.4	$p = 0.31$
D x F x P	F(2, 8) = 0.2	$p = 0.85$

Table S1: Results from 3 factor repeated measures ANOVA on the deviations presented in figure S2

We then imposed a strict constraint on deviation from fixation excluding any trials in which the mean absolute deviation over the trial was more than 0.25 degrees (15 arcmin). These data together with the associated mean deviations from fixation over observers are presented in figure S3. Deviations from fixation were on average around 0.15 degrees (9 arcmin). It is clear that these data are very similar to those seen in the manuscript (fig. 8).

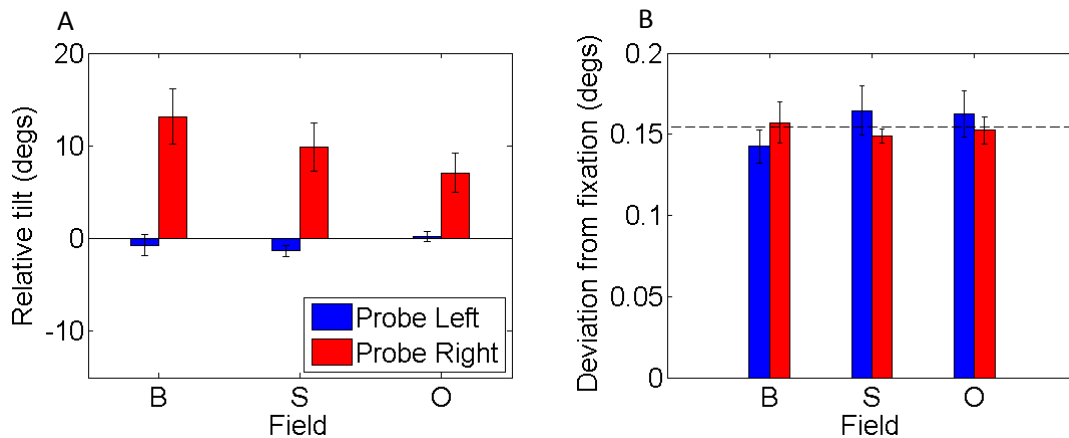


Figure S3: Similar to figure S1 but after exclusion of trials with mean deviation from fixation over trial exceeding 0.25 degree (15 arcmin).

In determining whether the relative tilt effects seen were driven by eye movements, it is useful to also examine eye traces over the course of the 2s trial. In figures S4 and S5 we present average (over observers and repetitions) eye movement traces for the duration of the 2s trials and for each of the 6 conditions. These data correspond to that presented in figure S3. If the relative tilt effects seen in figure S3A were driven by eye movements then we might predict some clear patterns in the data.

First we would predict that the horizontal deviations from fixation would be markedly different from the vertical deviations since the former should systematically drive the relative tilt effects but the latter should be due to pure fixation noise. However, examination of figures S4 and S5 does not suggest any obvious differences between the vertical and horizontal traces (this is also consistent with the statistical analysis above which suggests that the average deviations from fixation were similar in the horizontal and vertical directions).

Second, if the behavioural effects seen were driven by eye movements then when the probe was on the right we would expect to see a sustained movement of the eye to the right (to generate the relative tilt observed in figure S3A), whereas when the probe was on the left we would expect to see

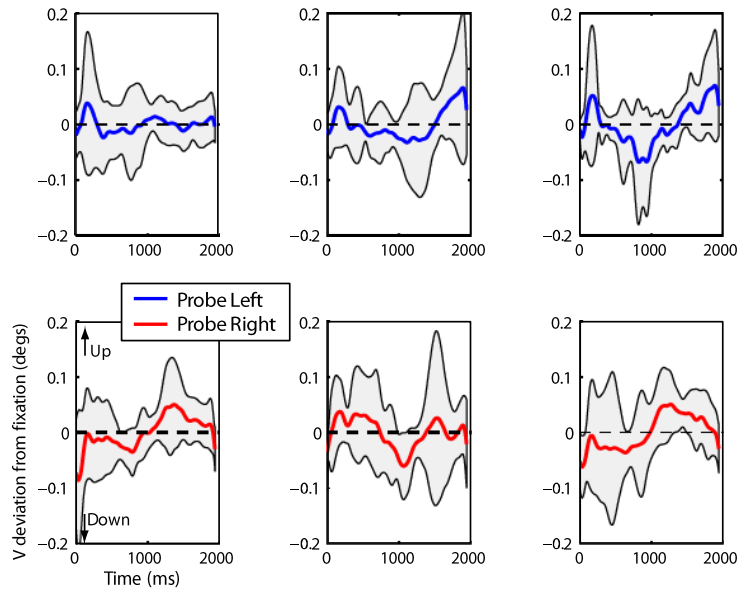


Figure S4: Average vertical eye movement traces (over observers and repetitions) for the 2s period of a trial. Shaded regions correspond to 95% confidence intervals.

no such movement (since there is relatively little relative tilt in figure S3A). Examination of figure S5 does not appear to support these predictions. There does appear to be a small early drift to the right in some conditions but, in contrast to the prediction, if anything this effect is more pronounced when the probe is on the left.

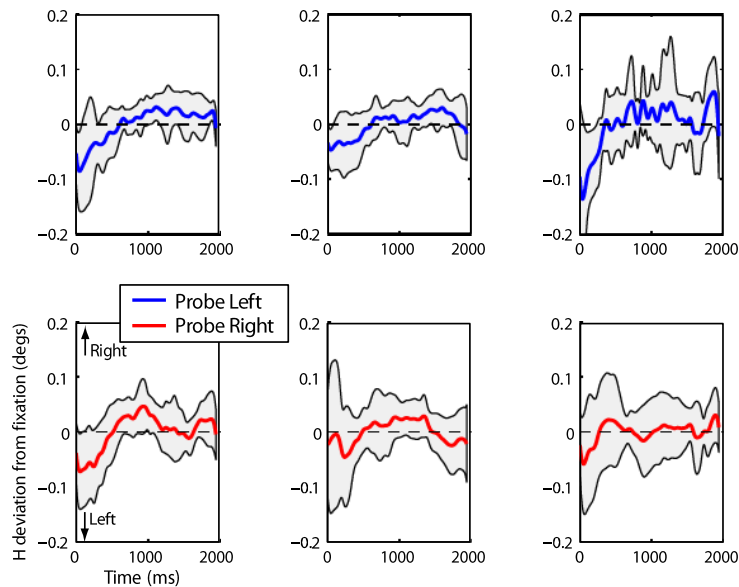


Figure S5: Average horizontal eye movement traces (over observers and repetitions) for the 2s period of a trial. Shaded regions correspond to 95% confidence intervals.

Third, given that the relative tilt effect was smallest in the “opposite” condition when the probe was on the right then we might also expect to see a smaller drift of the eye to the right in that condition relative to the other field structure conditions. Examination of figure S5 does not support this prediction. In short there do not appear to be any systematic differences between the average eye movement traces presented, that could predict the relative tilt data seen in figure S3A.

Discussion

Considering the fixation accuracy data in figures S1 & S2 it seems reasonable to conclude that deviations from fixation were relatively small. In addition, given that there was no real difference between vertical and horizontal eye deviations these are likely to represent non-systematic random fluctuations in eye position rather than be driven by some aspect of the flow stimulus. Furthermore, the average horizontal and vertical eye movement traces presented in figures S4 and S5 do not appear to follow any obvious systematic patterns. Consequently, based on the behavioural data in figures S1 & S3, which are similar to those presented in experiment 1 of the main document, we feel confident that our results are not based upon unwanted oculomotor effects.

REFERENCES

Champion, R. A. & Freeman, T. C. A. (2010). Discrimination contours for the perception of head-centered velocity. *Journal of Vision*, 10(6): 14, 1-9.