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Perceiving Monocular Regions in Binocular Scenes

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1. INTRODUCTION

Our visual systems combine the two, slightly different, retinal images to arrive at a stable and continuous percept of a given scene around us. While a large proportion of any scene is binocular, there are a host of regions that can only be seen by one eye. Rather than being ignored, these monocular regions are integrated with the surrounding binocular regions and their content is consciously accessible to us.

However, our perception of the information contained in monocular regions seems to be slightly different from that of information that is seen by both eyes (binocularly). Ono et al (2003)[1], for example, report that monocular regions appear slightly displaced and compressed, as if to 'fit' into the surrounding binocular space. Here we discuss two experiments that investigate our perception of monocular regions further.

We used two relative numerosity tasks to study whether monocular regions lead to a percept that is comparable to that of binocular regions, and we explored how the two types of regions are integrated to form a seemingly stable and continuous percept.

2. EXPERIMENTS

We used a display in which a background region is partially hidden, or occluded, behind a series of foreground vertical bars, akin to a 'picket fence' (see figure 1). Stimuli were computer generated and left and right eye views displayed side by side on a CRT monitor. A Wheatstone stereoscope was used to deliver one image to each eye.

With a suitable choice of fence width and fence-background distance, this stimulus can be manipulated such that the background plane is either only visible monocularly (as shown in figure 1) or some regions of the background are visible monocularly, and some binocularly.

Participants were sequentially presented with two stimuli in which the background plane contained two dimensional 'clouds' of dots. They were asked which of the two appeared more numerous. Judgements were made under no time constraints but each stimulus was presented for only 0.4s.

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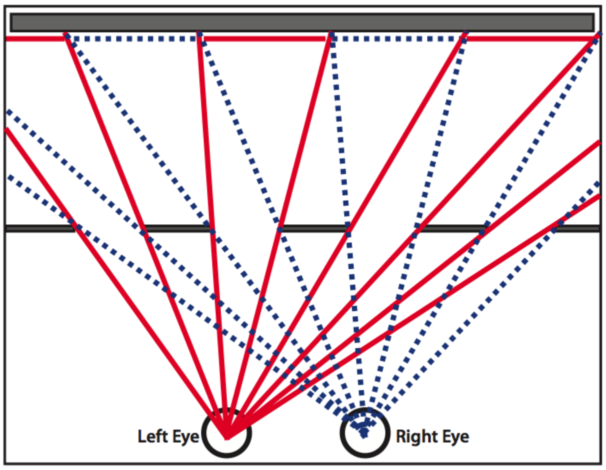

Figure 1: Picket-fence occluders that lead to a stimulus that contains only monocular regions in the background plane.

3. EXPERIMENT 1

In a first experiment, we asked whether monocular information can be used to perform a relative numerosity task. We compared a fully binocular stimulus with two occluded stimuli, one in which the visible information on the stimulus plane was binocular (generated by horizontally oriented foreground occluders), and one in which the visible information was monocular (generated by using vertically oriented occluders, as shown in figure 1): presented in 'natural' monocular regions. Figure 2 shows cartoons of the stimuli used.

We find numerosity discrimination to be as good for stimuli containing only monocular backgrounds (figure 2c) as for stimuli containing binocular ones (figure 2b), with participants responses showing neither a deterioration in accuracy nor in precision when judging stimuli with monocular regions.

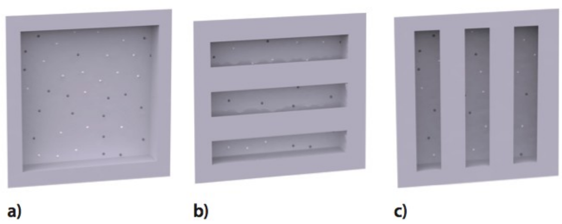

Figure 2: Cartoons of the stimuli used. a) fully binocular stimulus; b) stimulus in which the visible dots are binocular; c) stimulus in which the visible dots are monocular due to the occlusion.

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This suggests that participants are able to perceptually integrate monocular information, even when it is presented in spatially distinct regions. They respond to this monocularly presented information the same as they do to fully binocularly presented information.

3. EXPERIMENT 2

In a second experiment, we asked whether we use monocular information to the same extent as binocular information when the two have to be integrated to perform the numerosity task.

We compared stimuli in which some of the information on the background plane was visible binocularly and some of it could only be seen by one eye. These stimuli can be seen as comparable to a scene in which an object is partially occluded by another object. Unlike such a scene, the regions visible binocularly do not allow us to extrapolate to what the regions visible monocularly.

Here we find that if there is adjacent monocular and binocular information present, our performance is consistent with us completely disregarding the monocular information and relying solely on the binocular information to make the numerosity judgement.

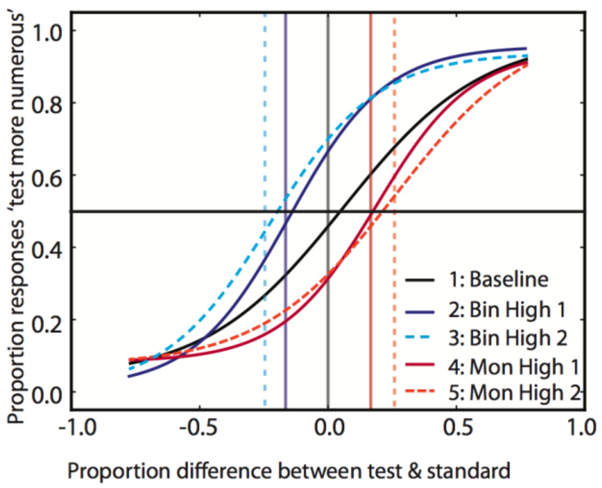

Figure 3: Fitted functions for participant bs for all conditions. The vertical lines are the predicted biases if the monocular regions were completely ignored and only the binocular regions compared across intervalls.

Figure 3 shows observer performance (expressed as proportion of responses judged as more numerous in the test stimulus) as a function of the proportion dot number-difference between the two stimuli. In the baseline condition monocular and binocular regions had the same density of dots, in 'bin high 1' the binocular regions contained 2/3 of the dots, in 'bin high 2' 3/4. 'Mon high 1' and 'mon high 2' used the same proportions but the monocular regions contained the higher number of dots.

Compare the observed bias (offset of the function from 0 along the x-axis) of the functions with the predicted bias (vertical line) for each condition if the monocular regions were completely ignored.

If the prediction is correct, each vertical line should intersect the fitted data function at the location of the 50% point (solid horizontal line). The data fall very close to this prediction. This bias means that people are behaving as if there were no dots in the monocular regions, relying solely on the binocular information.

4. DISCUSSION

Our experiments suggest that while we are able to use monocular information to make relative numerosity judgements, when we have access to binocular information as well, we prefer binocular over monocular information.

The fact that we are able to use monocular information suggests that it is not discarded as noise early on in processing. This fits with the subjective appearance of such regions as being continuous and part of our overall percept as well the results described by Ono and colleagues [1]. However, our inability to use monocular information when binocular information is present, even when the majority of visible dots are monocular (and we will thus arrive at a heavily biased percept), suggests that we might down-weight monocular information compared to binocular information when the latter is available.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

[1] H. Ono, L. Lillakas, P. M. Grove, and M. Suzuki, "Leonardo's constraint: Two opaque objects cannot be seen in the same direction.," Journal of Experimental Psychology: General, vol. 132, no. 2, pp. 253–265, Jan. 2003.