Chapter 6. Experiment 3. Motion sickness and vection with normal and blurred optokinetic stimuli

6.1 Introduction

Chapters 4 and 5 have shown that motion sickness and vection can be manipulated separately and may be distinct phenomena. Visual acuity has been shown to be correlated with motion sickness survival in all conditions, except during fixation. The association between visual acuity and survival time may possibly occur because it has an influence on eye movements which in turn influence motion sickness, or the detection of image slip on the fovea is somehow influencing motion sickness.

It was decided to test the possibility that artificial blurring of the stimulus viewed by subjects with good acuity could have the same effect as that of poor acuity. The experiment presented an artificially blurred optokinetic stimulus in one condition and compared the reports of motion sickness and vection with those arising from a normal optokinetic stimulus. It was hypothesised, with reference to model version 2 that vection would not differ between the two conditions because of the proposed peripheral dominance of vection. The removal of the high spatial frequency content of the stimulus, by artificial blurring, was predicted to increase motion sickness in the same way as poor acuity, the reasons for the effect still being unknown at this stage.

6.2 Method

Twenty subjects aged 18 - 28 years were selected for the experiment on the basis that they had good eyesight, which was defined for the purposes of this experiment as 20:20 vision or better, uncorrected, measured at the near point (0.4m) by the Landolt broken ring test, using the Keystone visual skills profiles.

The exposures consisted of moving visual stimuli presented on the Virtual Research VR4 head-mounted display (see Figure 6.1). The horizontal speed of the stripes was 30º/second as in all previous conditions. The blurring of the stripes in one condition was intended to reduce the resolution of the image presented by 50%. This was roughly estimated by using the blur parameter within the material editor of 3D Studio

MAX v1.2 and applying the blur to a bitmap image of text. The text in the image was of the same form as is commonly used in Snellen visual acuity tests, with increasingly small letters in horizontal lines. Eight lines of text were used and blur was applied until the bottom four lines of text were no longer readable, on the Virtual Research VR4 head-mounted display, with corrected vision. The resulting level of blur was noted and applied to the black and white striped image used in the optokinetic simulation. The blurring was applied to the source file in this way rather than by viewing the stimulus through blurring lenses which would have had a magnifying effect. The blurring had the effect of reducing the definition of the boundary between the black and the white stripes, so that there was a more gradual change from black to white, rather than a sharp edge (see Figure 6.1b).

Subjects were seated in the chair of the real optokinetic drum as used in all previous experimental conditions and the head of each subject was strapped to the back of the chair to prevent head movement. Each subject experienced both conditions, with 10 experiencing the normal condition first and 10 experiencing the blurred condition first. Exposure times were 30 minutes. There were two weeks or more between sessions to reduce effects of habituation and subjects experienced each condition at the same time of day. During the exposures, subjects rated their symptoms of motion sickness and vection as previously. After exposure, subjects completed the simulator sickness

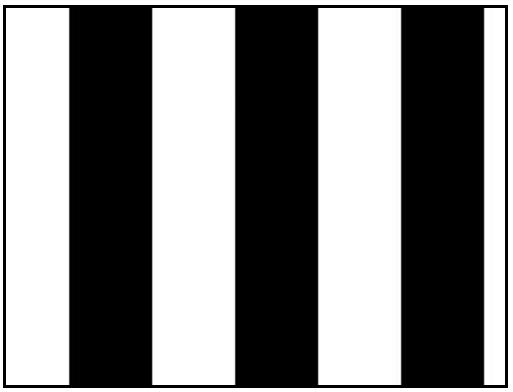

Figure 6.1a Normal stripes

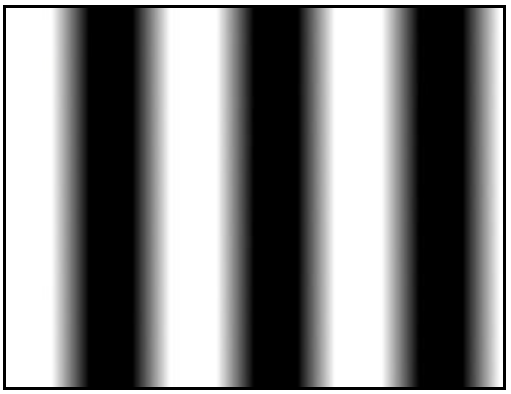

Figure 6.1b Blurred edges

questionnaire as previously used with the exception of the symptoms ‘blurred vision’ and ‘difficulty focusing’, which were removed!

6.3 Analysis

Motion sickness and vection scores across conditions were analysed using the Wilcoxon matched-pairs signed ranks test. Spearman's rank correlation test was used to test the relationships between vection and motion sickness in conditions. Survival analysis was performed as in Experiment 1 and Experiment 2.

6.4 Results

6.4.1 Motion Sickness

Accumulated illness ratings were calculated for each subject in both conditions. The mean accumulated illness rating for the normal condition was 39.5 and for the blurred condition was 40.8. There was no significant difference between the motion sickness ratings (Wilcoxon, $p>0.10$). The post exposure symptoms questionnaire showed there to be significantly more symptoms in the blurred condition (Wilcoxon, $p<0.05$). The mean illness ratings are shown against time in Figure 6.2.

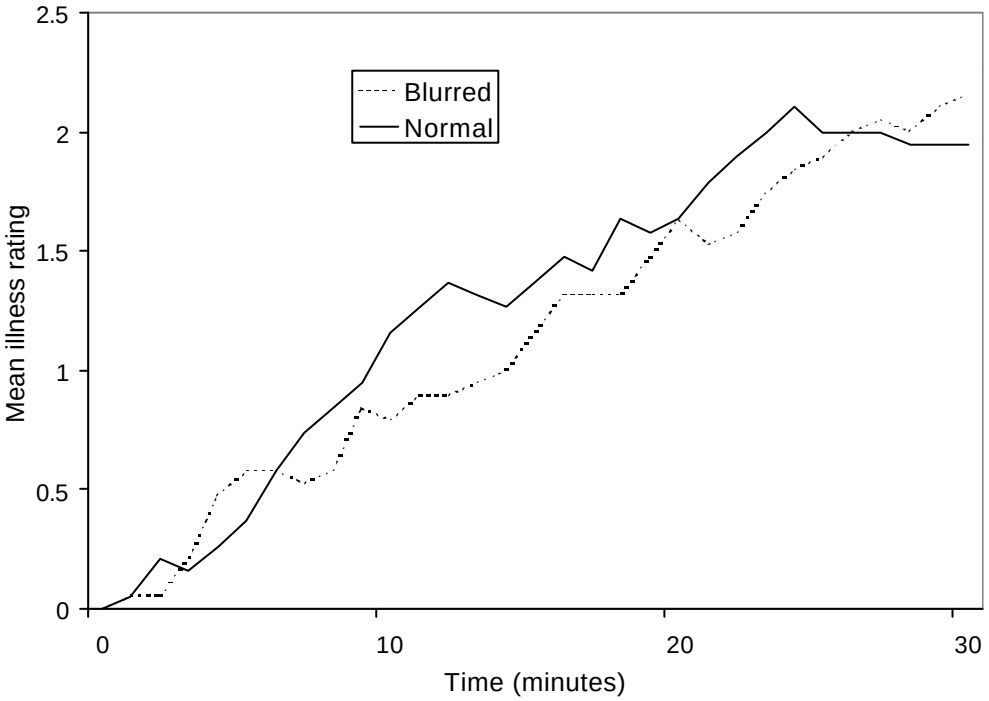

Figure 6.2. Mean illness ratings against time.

Subject motion sickness scores were correlated across the conditions ($\rho=0.620$, $p<0.01$) indicating that subjects who experienced motion sickness in one condition

also tended to experience motion sickness in the other. There were no correlations between accumulated vection scores and motion sickness scores in either the blurred (ρ=0.199, *p*>0.10) or the normal condition (ρ=0.130, *p*>0.10), see Figures 6.5 and 6.6.

6.4.2 Vection

There was no significant difference between the vection scores in the two conditions (Wilcoxon, *p*>0.10). There was a significant correlation between subject vection scores across conditions (Wilcoxon, *p*<0.001), indicating that subjects perceiving vection in one condition also tended to perceive vection in the other condition.

6.4.3 Survival analysis – normal condition

In the normal condition there was no correlation between survival time and subject visual acuity measured at the near point (ρ=-0.297, *p*>0.10) or measured at the far point (ρ=-0.215, *p*>0.10). Past susceptibility was not found to be correlated with survival time (ρ=-0.352, *p*>0.10) in this condition. Figure 6.3 shows the scatter plot of visual acuity at the near point and survival time for the normal condition.

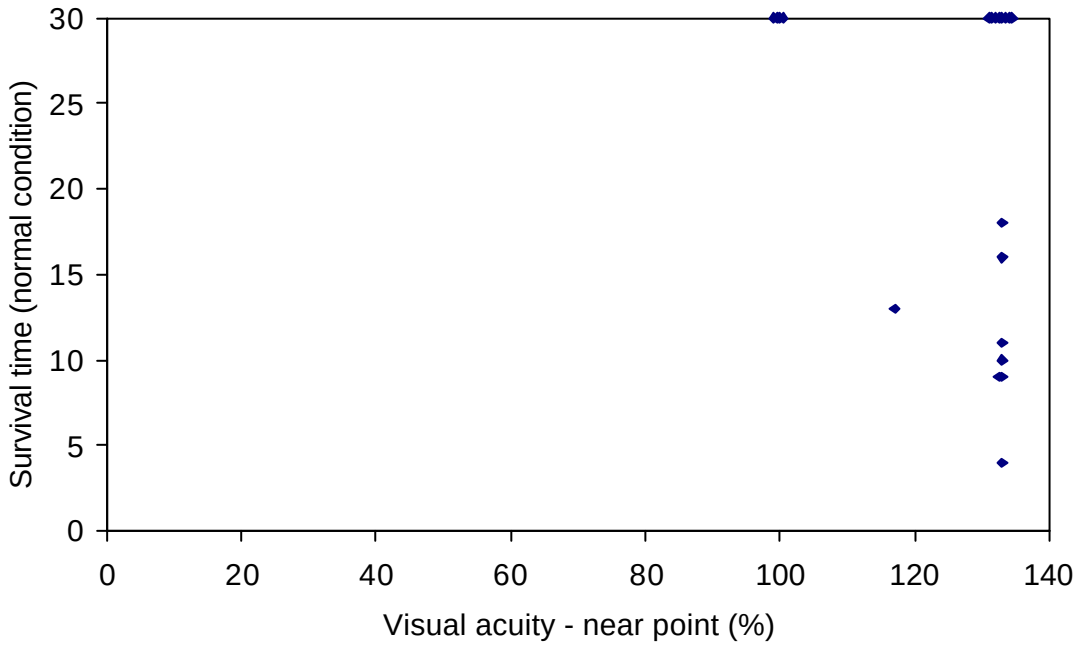

Figure 6.3. Variation of survival time with visual acuity for the normal condition.

6.4.4 Survival analysis – blurred condition

In the blurred condition there was no correlation between survival time and visual acuity at the near point (ρ=-0.204, p>0.10) or at the far point (ρ=-0.002, p>0.10). Past susceptibility was not correlated with survival time (ρ=-0.059, p>0.10). Figure 6.4 shows the scatter plot for visual acuity at the near point and survival time.

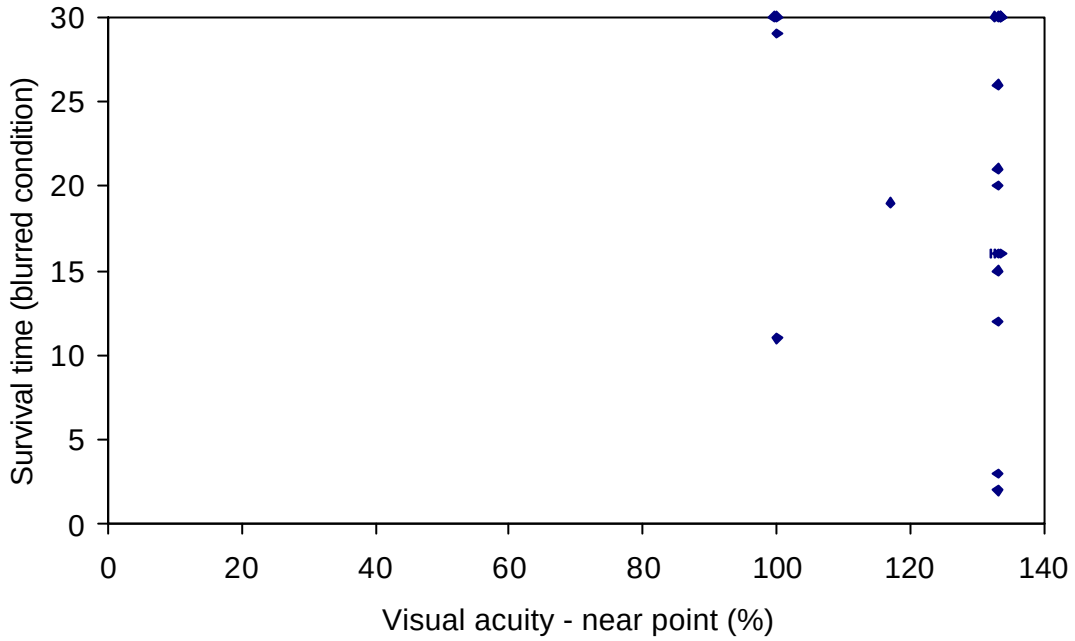

Figure 6.4. Variation of survival time with visual acuity for the blurred condition.

6.4.5 Cox's proportional hazards model

No significant correlations were found in the survival analysis, as shown above, therefore no Cox regression model was necessary.

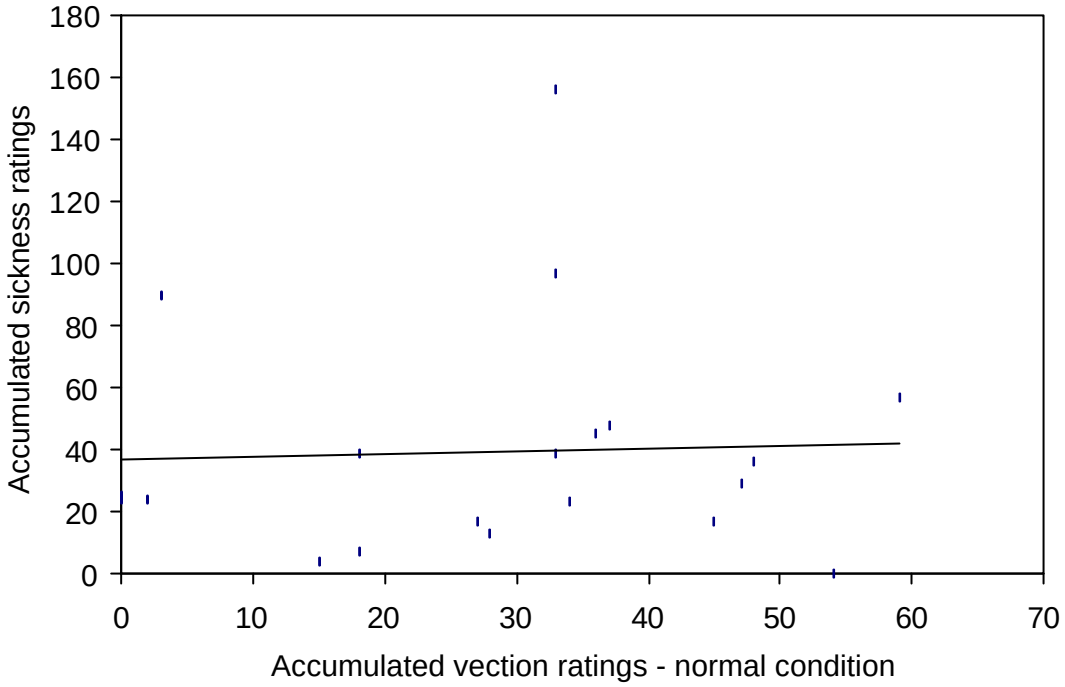

Figure 6.5. Vection and motion sickness scores in the normal condition.

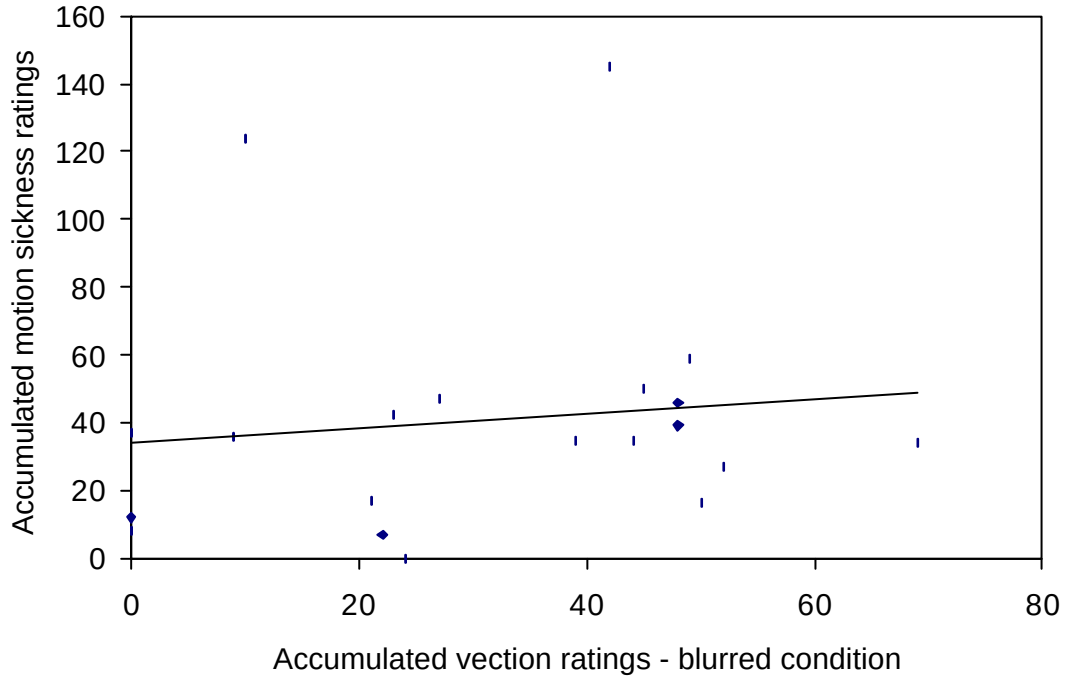

Figure 6.6. Vection and motion sickness scores in the blurred condition.

6.5 Discussion and conclusions

The conclusion drawn from Experiments 1 and 2, that vection and motion sickness are not related but are separate phenomena, is supported by this experiment. There were no correlations found between motion sickness and vection. Vection was also found to be similar in both conditions despite the artificial blur effect in one condition. Peripheral vision is not as sensitive to high spatial frequencies as the fovea. Removal of some of the high frequency content from the visual stimulus, by blurring, may not have changed the visibility of the stimulus in the periphery. This may explain why vection, which is probably controlled mainly by peripheral vision, did not vary between the normal and blurred conditions.

Accumulated illness ratings were not significantly different between conditions but post exposure symptoms were significantly different. This suggests that the artificial blur was only partially successful in the aim of increasing motion sickness.

It is possible that the artificial blurring of the stimulus may not have been completely successful in simulating poor visual acuity. The effect of the blur was to smear the boundary between the black and the white stripes. It may be that visual acuity has an effect on motion sickness which is not simply related to the amount of visual blur present. It may also be the case that there were some high frequency components left in the visual display, for example a straight edge can still be seen where the blurred boundary between the black and white stripes ends (Figure 6.1b). The increased symptoms reported post-exposure may suggest that the visual blur had some increased effect on motion sickness incidence. However, this result should be treated with caution at this stage.

Visual acuity was not significantly correlated with survival time in either condition. This is not surprising because all subjects had visual acuity as measured by the Landolt ‘broken ring’ test of 20:20 of greater. There was not enough variation in the visual acuity to see any significant correlations.

6.6 Updated Model

The possible effect of visual blur on motion sickness is added into the model (see

Figure 6.7). As with the visual acuity influence it is shown to act on the foveal pursuit component of the slow phase of nystagmus. The influence is shown with a dotted line to show that it is uncertain. The rest of the model remains unchanged. The peripheral influence on vection was confirmed, as were the distinct outputs for vection and motion sickness.

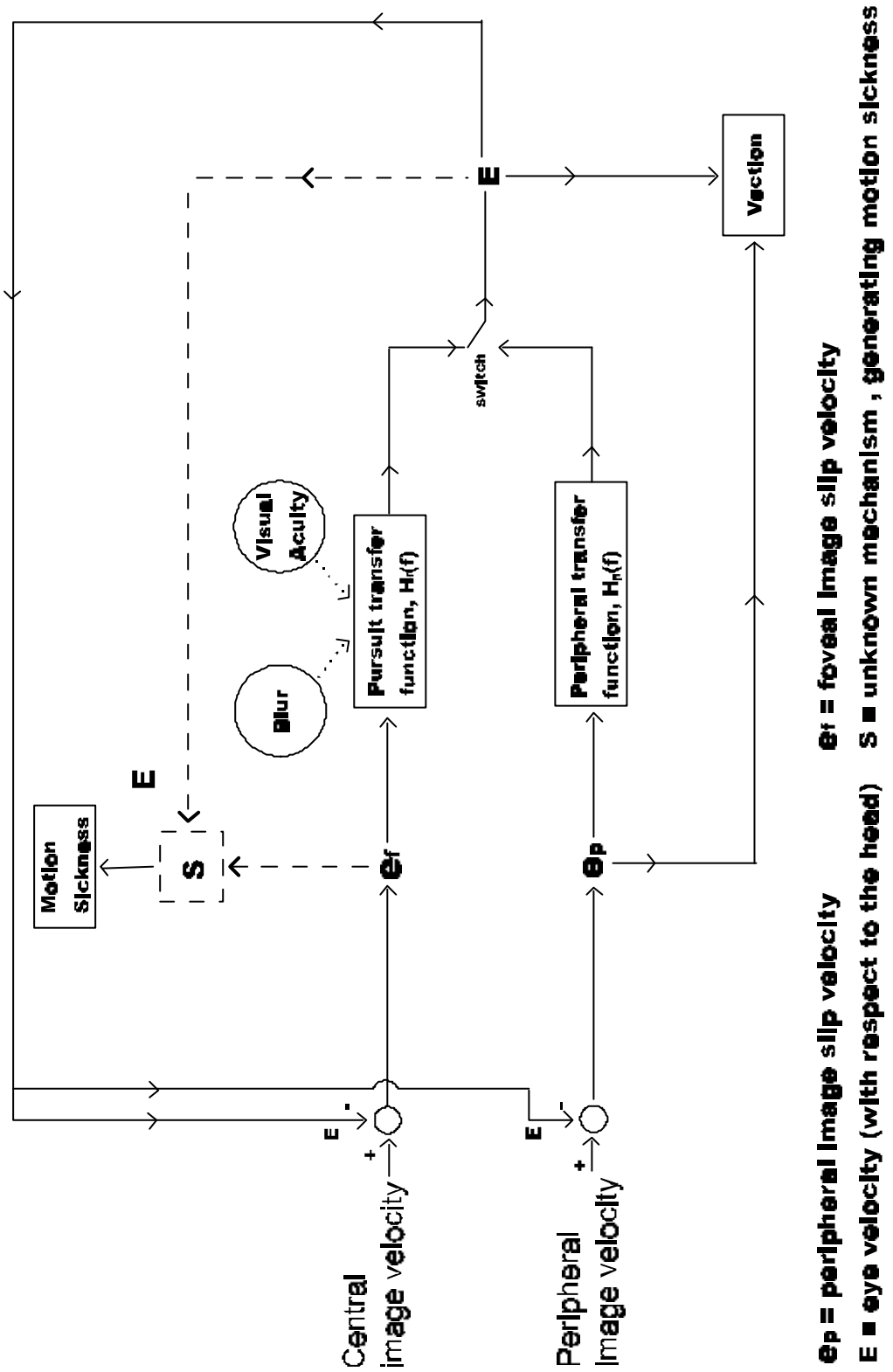

Figure 6.7. Model version 3. Updated model to show the possible influence of artificial blur.