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ABSTRACT

FACULTY OF ENGINEERING AND APPLIED SCIENCE
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Doctor of Philosophy

VISUAL ACUITY, EYE MOVEMENTS, THE ILLUSION OF MOTION AND MOTION SICKNESS WITH OPTOKINETIC STIMULI

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Motion sickness and the illusion of self-motion (vection) can be induced by the use of an optokinetic drum (a black and white striped cylinder which rotates around a seated, stationary subject). It has been suggested that vection is a cause of motion sickness in optokinetic drums because the illusion of self-motion, in the absence of real motion, may be a form of sensory conflict. Alternative theories have suggested that motion sickness may arise from eye movements. Motion sickness has been reduced with fixation, where subjects focused on a stationary object in front of the moving stripes, preventing eye movements.

This thesis investigated the correlations between motion sickness, vection, eye movements and visual acuity. Six experiments were conducted. The first compared motion sickness and vection in a real and a virtual reality simulation of an optokinetic drum (with the same field of view). There was slightly greater motion sickness in the real drum, but no difference in vection. Vection and motion sickness scores did not correlate within conditions, indicating that vection may not be the main cause of motion sickness. It was found that visual acuity was significantly correlated with motion sickness, in both conditions. Subjects with poor acuity reported increased symptoms.

In the second experiment subjects viewed a normal optokinetic stimulus on the virtual reality display and the same optokinetic stimulus with a stationary cross in front of the moving stripes (fixation). Motion sickness was significantly reduced with fixation but vection was unchanged. Visual acuity was correlated with motion sickness without fixation, as before, but was not correlated with motion sickness with fixation. The fourth experiment found that motion sickness could be produced with a single moving dot, tracked by the eyes of subjects, presented on the virtual reality display. Motion sickness symptoms were not significantly different with a single or multiple dot display. Vection was significantly higher with multiple dots, where peripheral visual stimulation was increased.

A fifth experiment found that motion sickness was significantly higher when subjects viewed a standard optokinetic drum without vision correction, compared to viewing with vision correction. Visual acuity and contrast sensitivity to higher spatial frequencies were found to be correlated with motion sickness, indicating that a lack of sensitivity at high spatial frequencies, rather than at a wide range of low and high spatial frequencies, were associated with motion sickness. A final experiment measured the slow phase of nystagmus with and without vision correction. It was found that the slow phase velocity was significantly lower with poorer sensitivity to high spatial frequencies.

The results from the experimental work suggest that vection and motion sickness are distinct phenomena, since they can be manipulated independently, and were not correlated in any of the experimental conditions. Motion sickness was not significantly different with a single dot (foveal) or multiple dot display (foveal and peripheral), and was reduced by fixation (where there was no foveal image slip, but large peripheral image slip). It is concluded that foveal image slip may be an influence on motion sickness via an unknown mechanism. Vection is controlled mainly by peripheral image motion and is unrelated to eye movements. Contrast sensitivity to high spatial frequencies influenced the amount of foveal image slip occurring, which in turn influenced motion sickness. A model of the interactions between visual acuity, vection, foveal and peripheral image slip, motion sickness and the slow phase velocity of nystagmus has been developed.