Translations do affect vestibular stabilization performance
Markus von der Heyde & Heinrich H. Bülthoff
Max Planck Institute for Biological Cybernetics

1 Introduction
We investigated the usability of vestibular translatory motion cues in self stabilization. Six blindfolded observers were asked to control the pitch or roll axis (see Fig. 1) of a Stewart motion platform (see Fig. 2) which followed the movements of a virtual inverse pendulum. We varied the height of the pendulum’s turning axis with respect to the observer’s head (see Fig. 3). Shifting the turning axis along the body axis leaves the vestibular rotational cues identical while changing only the translatory component of the motion.

2 Hypotheses
I) If the translatory components do not affect stabilization, performance should be equal for all conditions.
II) If translation does affect stabilization, then increasing the distance between the head and the turning axis should systematically alter performance.
III) In posture control, humans always rotate (tilt) around points below the head and therefore those conditions should result in better performance.

3 Methods
The experimental paradigm
Subjects controlled the pendulum with a virtual force proportional to the deflection of a joystick (acceleration based control). Five different turning axis heights with respect to the head (h=0.0m, ±0.6m, and ±1.2m) were tested in trials that lasted 60 seconds each. The experiment consisted of 12 repetitions of all heights (performed in three blocks with four repetitions each). Observers typically reached a stable performance during the second block (i.e., after about 30 minutes of training). To exclude learning artifacts, we limited the analyses to the last four repetitions of all heights.

4 Results
We measured performance across the last four repetitions by means of absolute error and variability of position and velocity (see Figures on the right; the whiskers depict one standard deviation of the mean and the boxes indicate the standard error). Surprisingly, the final performance was best for the condition where the turning axis was 0.6m above the head. Also the amount of steering (= subject controlled accelerations) as well as the accumulated time of boundary collision reached the minimum at this condition. Performance decreased with increasing distance from this optimum. Therefore, none of our hypotheses were confirmed.

These results can help to design better helicopter simulators and optimize simulator training. Speculations about evolutionary explanations of our results (imagine swinging monkeys) await further investigation.

5 Conclusions
Subjects stabilized themselves on a simulated inverse pendulum. We measured performance by means of absolute position or velocity and their respective variance. Observers typically reached a stable performance during the second block (i.e., after about 30 minutes of training). To exclude learning artifacts, we limited the analyses to the last four repetitions of all heights.

Poster presented at the 5. Tübinger Wahrnehmungskonferenz 2002

Subject controlled the pendulum with a virtual force proportional to the deflection of a joystick (acceleration based control). Five different turning axis heights with respect to the head (h=0.0m, ±0.6m, and ±1.2m) were tested in trials that lasted 60 seconds each. The experiment consisted of 12 repetitions of all heights (performed in three blocks with four repetitions each). Observers typically reached a stable performance during the second block (i.e., after about 30 minutes of training). To exclude learning artifacts, we limited the analyses to the last four repetitions of all heights.