# Effects of symmetry, texture, and monocular viewing on geographical slant perception


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## INTRODUCTION

Hills often appear to be steeper than they are. The unusual magnitude of this error has prompted extensive experimentation. The judgement mode, such as verbal vs. action based measures, the state of the observer – whether exhausted or well rested – all can influence perceived geographical slant. We hold that slant perception is inherently shaky as soon as the slope in question is no longer palpable, that is if it is outside our personal space. To make this point, we have added symmetry, texture, and depression to the list of factors that might modulate slant perception. When the frontal slope of a hill is to be judged, it appears steeper when the side slopes are steep. We have used model hills close to our subject. Their slopes were judged most accurately when binocular stereoscopic vision was permitted. When closing one eye, observers grossly overestimated all slopes. This error was larger for verbal judgements than for judgements made by indicating the slope with their forearm, however, the pattern of the overestimation remained unchanged. Surface texture mattered surprisingly little. Depressed subjects produced exactly the same results as healthy controls. We conclude that in action space and in vista space, slopes are overestimated because the visual system attempts to turn the 2D retinal stimulus into a regular 3D object, akin to the erection tendency (Aufrichtungstendenz) found in diminished or 2D-stimuli. This tendency is inherently instable and can be swayed by a large number of variables.

## METHODS

### Stimuli and Design

For purposes of stimulus control, we investigated slope estimation in an artificial laboratory setting in a laboratory room of the Psychology Department of Johannes Gutenberg-Universität Mainz (Fig. 1). We constructed an artificial hill with a height of 30 cm. It had a central piece to which various front and side ramps could be attached. All pieces were made of Styrofoam and coated with gypsum and a non-reflective white paint. The frontal ramp, a large wedge sloped by 17°, 30°, 43°, 56°, 69° and 82, and the two side ramps (sloped 27° and 66° each) could be arbitrarily combined. The space between frontal and side ramps was likewise filled with Styrofoam pieces (30 cm high) to form a smooth hill

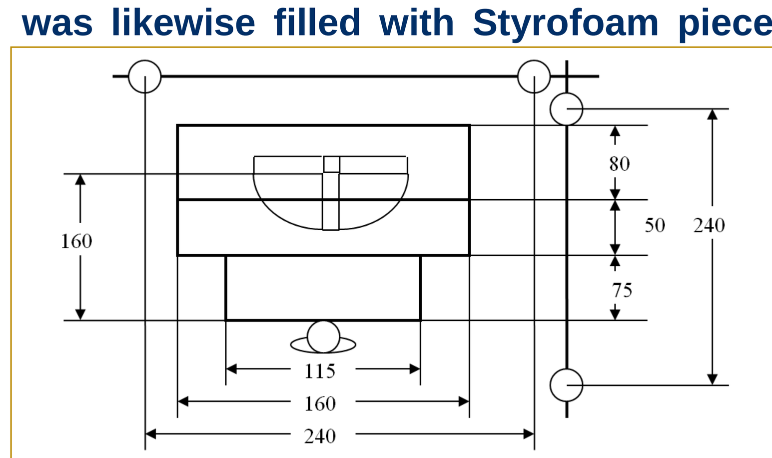


*Figure 1.* Experimental setup. All measures are in centimeters.

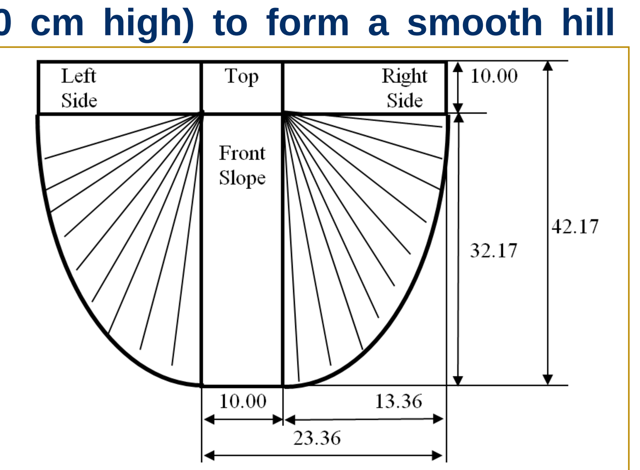


*Figure 2.* Dimensions of the Styrofoam hill (aerial view) for a stimulus with a frontal slope of 43° and two side slopes of 66° as well as two lateral curved connecting parts.

### Subjects

The subjects were naïve to the purpose of the experiments. The head was steadied by a chin rest such that eye-height was about 10 cm above the table surface with free view straight ahead to the frontal ramp.

| | Condition | Total | Gender ♂ | Gender ♀ | Age |
|---|---|---|---|---|---|
| Experiment 1a | binocular | 21 | 5 | 16 | 19 – 35 (M = 24.52, SD = 4.355) |
| Experiment 1b | monocular | 22 | 2 | 20 | 20 – 40 (M = 25.91, SD = 4.418) |
| Experiment 1 | complete | 43 | 7 | 36 | 19 – 40 (M = 25.23, SD = 4.391) |
| Experiment 2 | Control group | 47 | 5 | 15 | 19 – 39 (M = 23.64, SD = 4.445) |
| | Experimental group | 42 | 13 | 29 | 18 – 61 (M = 38.00, SD = 11.363) |

Subjects were instructed to estimate the degree of the frontal ramp, verbally and by indicating the estimated slope by the angle between their forearm and the table top.

## RESULTS

### Experiment 1: Monocular and binocular frontal slope estimation

In experiment 1, we tested the influence of different side slopes on verbal estimation of the frontal slope. In the first part of the experiment, subjects viewed the stimuli with both eyes, in the second part, one eye was covert. Steep side slopes should lead to an overestimation of the frontal slopes, whereas shallow side slopes should not have this effect (or an opposite effect in the case of steep frontal slopes). Binocular viewing should weaken or entirely destroy the effect, given that the hill was well within personal space and in the range of stereopsis. In contrast, a model in monocular viewing should produce results that are comparable to real world viewing.

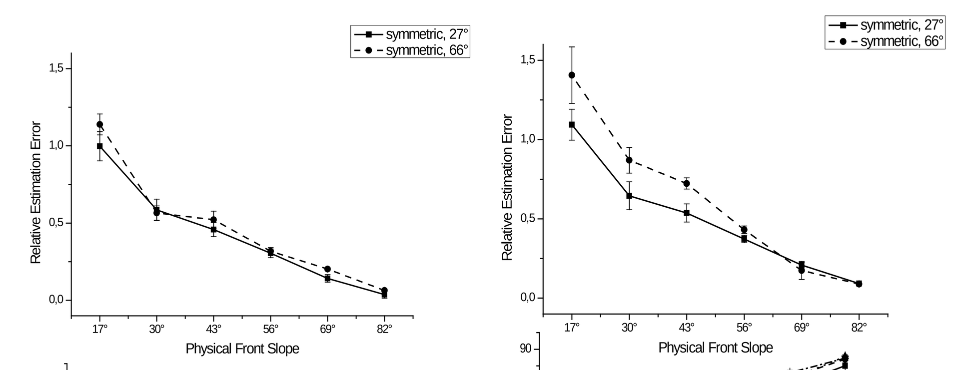

*Figure 3.* Relative overestimation of frontal slopes as a function of actual slope separately for shallow and steep symmetric of side slopes. Values correspond to binocular (left graph) and monocular (right graph) viewing. Error bars indicate standard errors of the mean.

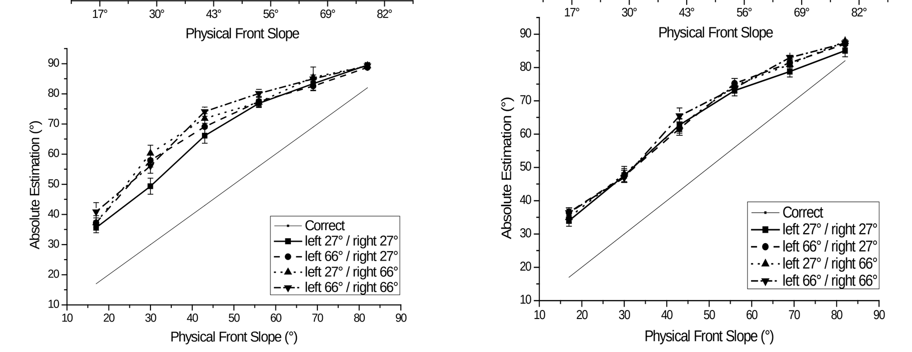

*Figure 4.* Absolute overestimation of frontal slopes as a function of actual slope separately for symmetric and asymmetric of side slopes and viewing condition. Values correspond to binocular (left graph) and monocular (right graph) viewing. Error bars indicate standard errors of the mean.

| Factor | *F* | *df1* | *df2* | *p* | $\eta^2$ | ε |
|---|---|---|---|---|---|---|
| Front slope | 189.086 | 5 | 205 | .000 | .822 | .343 |
| Front × condition | 2.760 | 5 | 205 | .078 | .063 | |
| Side slope left side | 6.147 | 1 | 41 | .017 | .130 | 1.000 |
| Left × condition | .476 | 1 | 41 | .494 | .011 | |
| Side slope right side | 13.755 | 1 | 41 | .001 | .251 | 1.000 |
| Right × condition | 5.313 | 1 | 41 | .026 | .115 | |
| Front × left slope | 2.475 | 5 | 205 | .077 | .057 | .496 |
| Front × left slope × condition | .756 | 5 | 205 | .489 | .018 | |
| Front × right slope | 1.516 | 5 | 205 | .224 | .036 | .445 |
| Front × right slope × condition | 1.334 | 5 | 205 | .269 | .032 | |
| left × right slope | 1.408 | 1 | 41 | .242 | .033 | 1.000 |
| left × right slope × condition | .290 | 1 | 41 | .593 | .007 | |
| Front × left slope × right slope | 2.709 | 5 | 205 | .056 | .062 | .530 |
| Front × left slope × right slope × condition | 3.288 | 5 | 205 | .028 | .074 | |
| Condition | 10.038 | 1 | 41 | .003 | .197 | |

*Table 1.* Experimental 1 a and b – results of rmANOVA for slope estimation..

All front slopes were overestimated in all conditions (Fig. 3). Even the almost vertical slope of 82° was overestimated. We could also confirm our hypothesis and found a particularly strong tendency to overestimate the slope of the frontal ramp as a function of side slope steepness. The effect was modulated by the viewing condition and was even stronger when subjects had to estimate the slope monocularly. In the binocular condition, the side slope did not have an influence on the frontal slope estimation (Fig 4).

### Experiment 2: Frontal slope estimation – varying texture and answering mode

In the second experiment, we tested the influence of different side slopes on the estimation of a frontal slope for three kinds of texture, and two different answering modes. Given the controversy regarding the state-dependency of perception, we chose to include a group of depressed subjects whose mental energy should be seriously reduced in the sense of this state-dependency hypothesis. We also hypothesized that the haptic measure would be more accurate than the verbal measure. We used a table surface as haptic reference for the forearm. Finally, we varied the texture of the slope. A texture that is compressed as compatible with a lower eye-height should produce slope overestimation.

| Factor | *F* | *df1* | *df2* | *p* | $\eta^2$ | ε |
|---|---|---|---|---|---|---|
| Front slope | 564.976 | 4 | 344 | .000 | .868 | 1.000 |
| Answering Mode | 125.079 | 1 | 86 | .000 | .593 | 1.000 |
| Texture | 49.167 | 2 | 172 | .000 | .364 | 1.000 |
| Side slope | 208.304 | 1 | 86 | .000 | .708 | 1.000 |
| Front × answer | 5.753 | 4 | 344 | .002 | .063 | .901 |
| Front × side | 15.362 | 4 | 344 | .000 | .152 | .992 |
| Answer × side | 27.692 | 1 | 86 | .000 | .244 | .999 |
| Front × answer × side | 5.219 | 4 | 344 | .006 | .057 | .830 |

*Table 2.* Experimental 2 – results of rmANOVA for slope estimation (only significant values).

As before, slopes were overestimated in all conditions. The hypothesized effects of texture and side slope were found. As in Experiment 1, the steeper symmetric side slope produced larger overestimation both in the haptic and the verbal condition. Verbal slope estimation produced consistent overestimation, whereas the haptic answering mode did not.

## RESULTS

The effect size of texture was weaker than those for slope and answering mode. The compressed shallow texture produced underestimation, the steep one the expected overestimation.

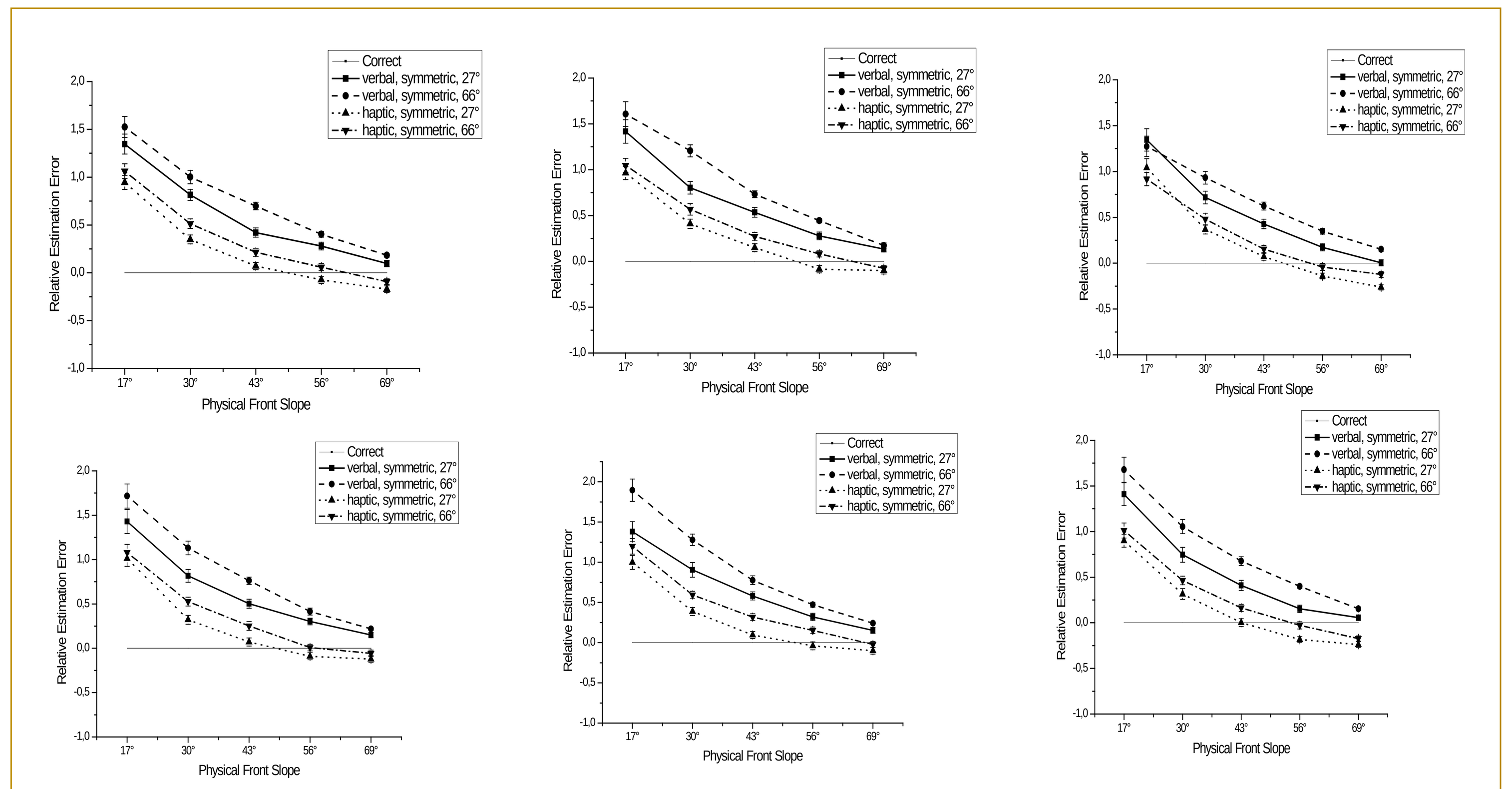

*Figure 5.* Slope estimation of the control (1st row) and the experimental group (2nd row) for regular (column 1), compressed steep (column 2), and compressed-shallow frontal (column 3) slope texture. Error bars show the standard error of the mean.

We could also confirm our symmetry hypothesis and found larger overestimation of the frontal ramp as the sides slopes were steep.

The sample of depressed patients did not differ from the student group [F(1, 86) = 0.84, p = 0.36, η2p=0.01, ε=.15]. One could argue that the model slope did not sufficiently evoke an increased effort as would be required to climb a large hill.

## DISCUSSION

In our first experiment we have modified the immediate vicinity of the slope that had to be judged. The shape of irrelevant parts of the hill had a significant effect on the target slope. The results point to a straight-forward integration of the irrelevant side slopes with the relevant front slope. The latter was judged to be particularly steep when both adjacent sides of the hill were steeper. When the side slopes were not symmetric, their influence on the target slope was attenuated. This finding seems to indicate that even pictorial information of secondary nature intrudes upon slant judgements.

In the second experiment we took a closer look at answering mode, subject variables, and slope texture. Rating errors were generally reduced with the forearm method, and subject variables had no effect (age, depression). Texture appeared to be a weaker cue than others. Note that we used a reduced laboratory task, and texture was adapted to the small scale ramp setting, so that the black and white horizontal stripes of the texture might have reduced the normal impact of texture.

We can summarize that judgements of geographical slant are volatile and even more prone to extraneous influences than previously thought. Various reference cues and viewing conditions do alter the perceived slope.

## DISCLOSURE INFORMATION

- I have no financial relationships to disclose.
- I will not discuss off-label use and/or investigational use in this poster.

## Literature


Daum, S. O. & Hecht, H. (2018). Effects of symmetry, texture, and monocular viewing in geographical slant estimation. *Consciousness and Cognition, 64*, 183-195.



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