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No Visual Dominance for Remembered Turns

Psychophysical Experiments on the Integration of Visual and Vestibular Cues in Virtual Reality

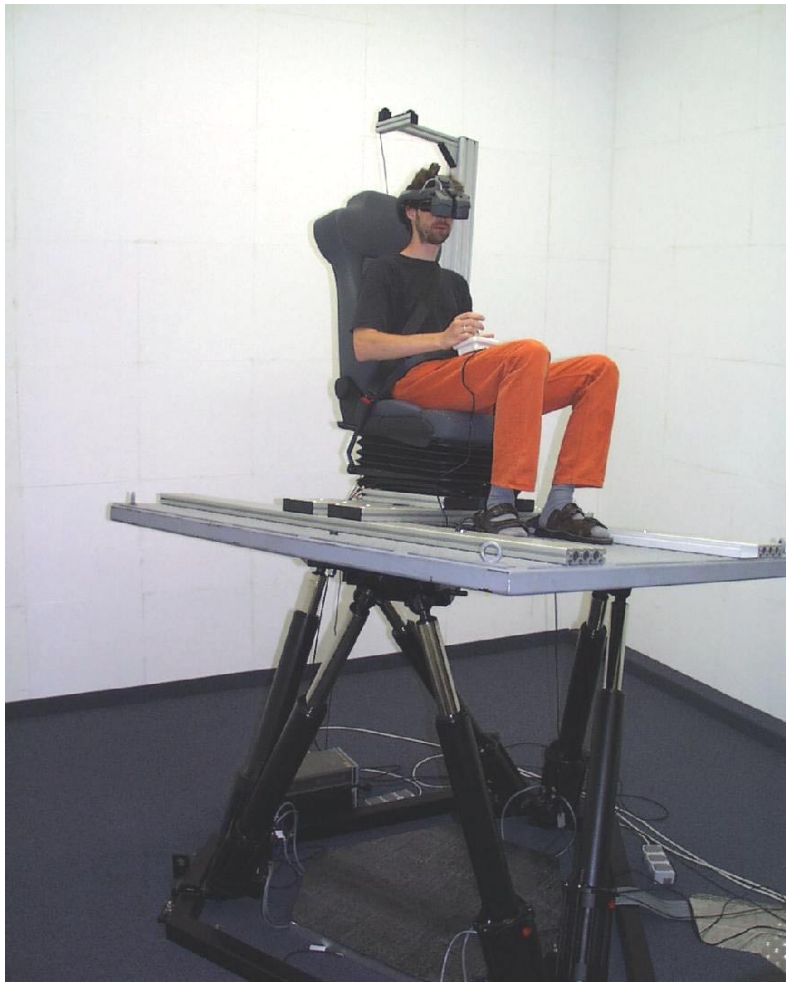
Experimental questions

- In most virtual reality (VR) applications ego-turns are misperceived.
- We investigated visual and vestibular turns:
  - Are both visual and vestibular information stored and can they be reproduced later?
  - Are both modalities integrated into one coherent percept or is the memory modality specific?

Task: learn and reproduce visual-vestibular turns

- Procedure:
  - two groups (**active** and **passive**) learned a sequence of turns (8.5, 12 and 17 deg.) and reproduced this sequence with changed visual and vestibular gain factors ($1/\sqrt{2}$, 1,$\sqrt{2}$).
  - the active group followed a vestibularly defined path.
  - the passive group was guided along the same path.

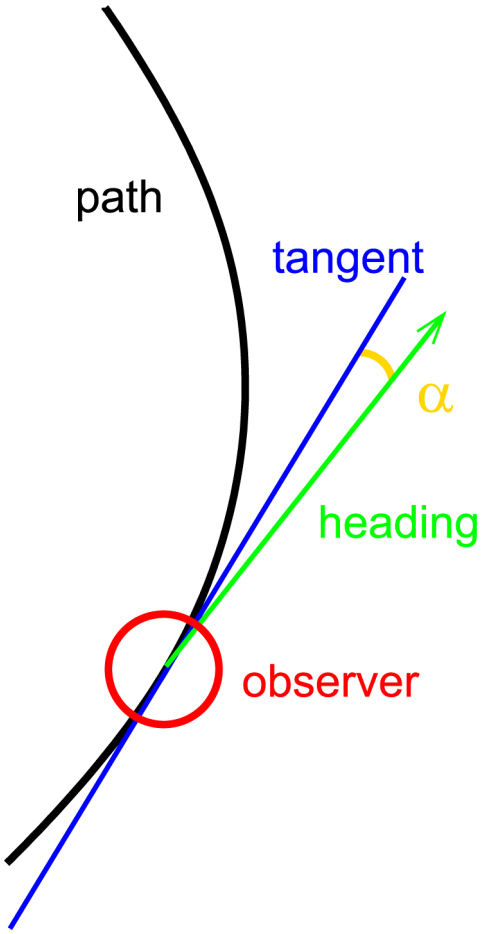
Turning simulation



- visual stimuli: optic flow during turns with constant forward motion as optic flow inside the HMD
- vestibular stimuli: horizontal turns (yaw) with motion platform
- auditory cues: excluded via headphones

→ simulate relevant turn information

How to follow a vestibular path

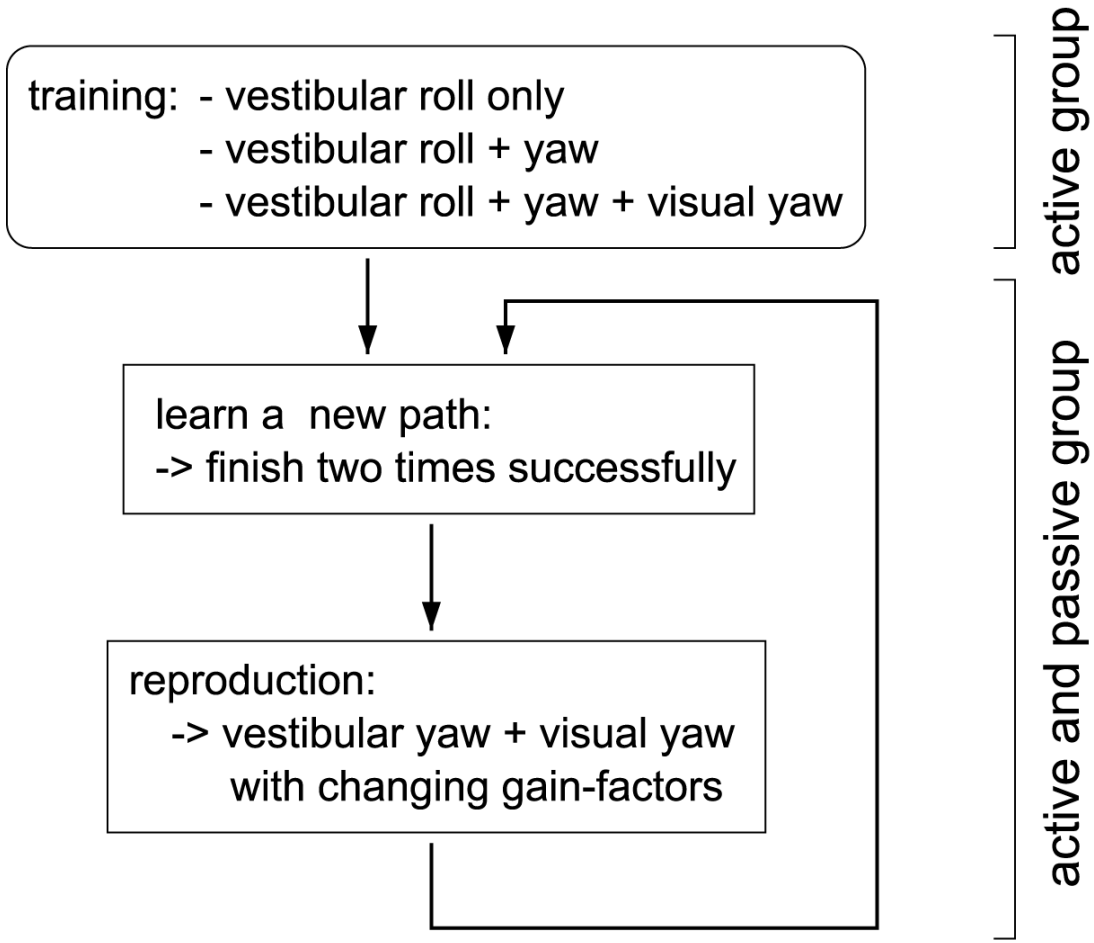


- path as sequence of turns
- deviation: $\alpha \rightarrow$ roll rotation
- task: hold platform upright
- control heading to adjust roll

$\rightarrow$ subjects follow a vestibular path

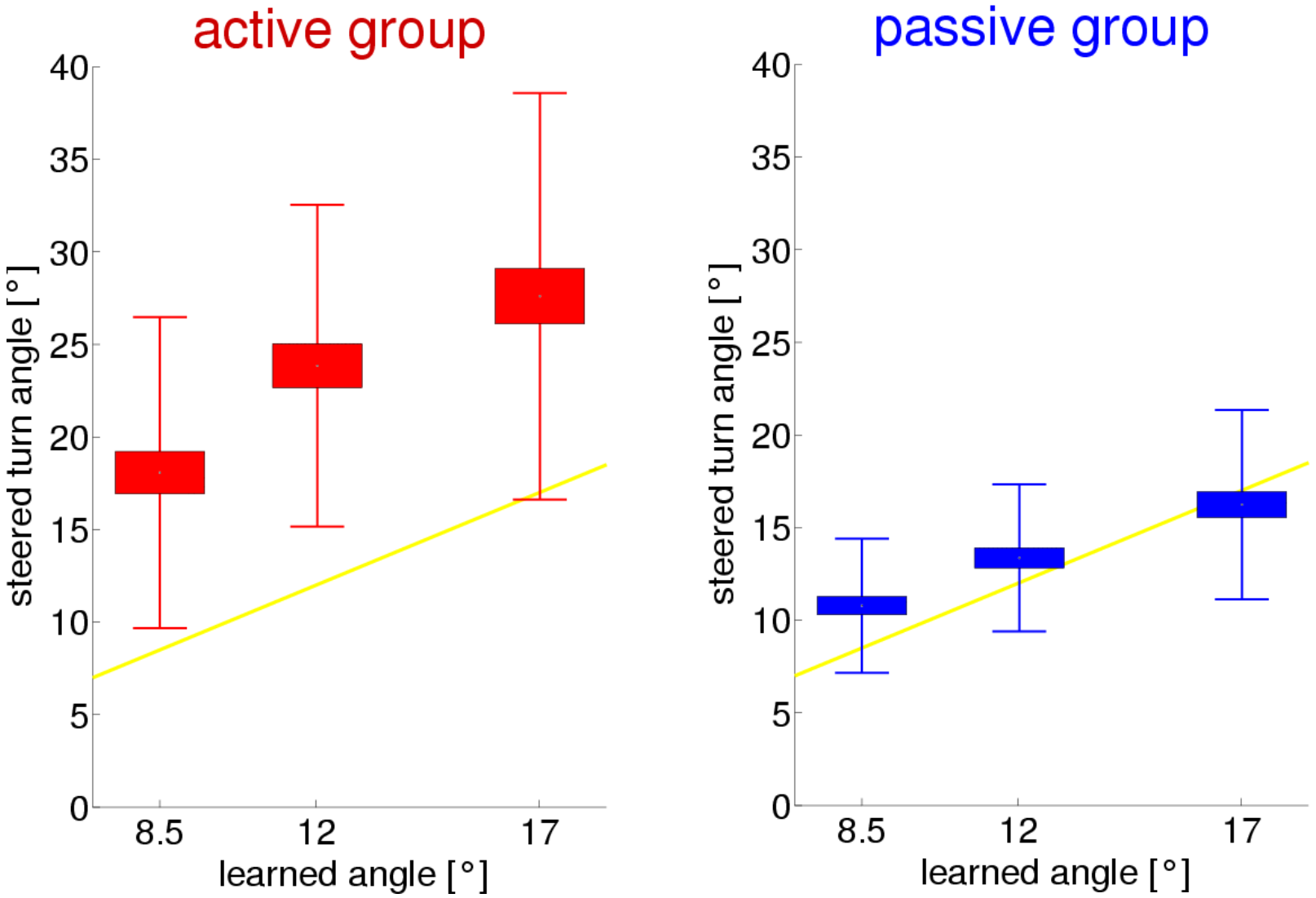
like in a bobsled.

Experimental design

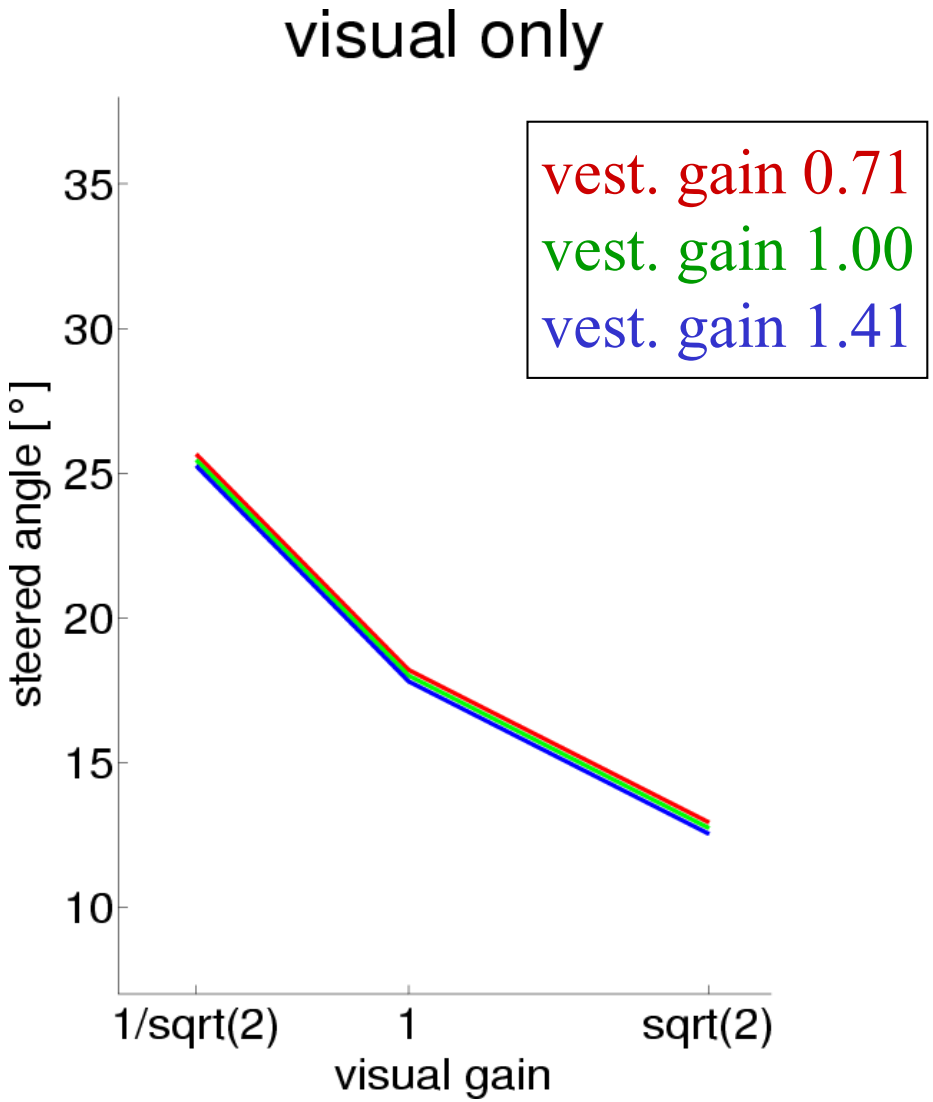


Reproduced turns – no gain

(n=6 subjects each)

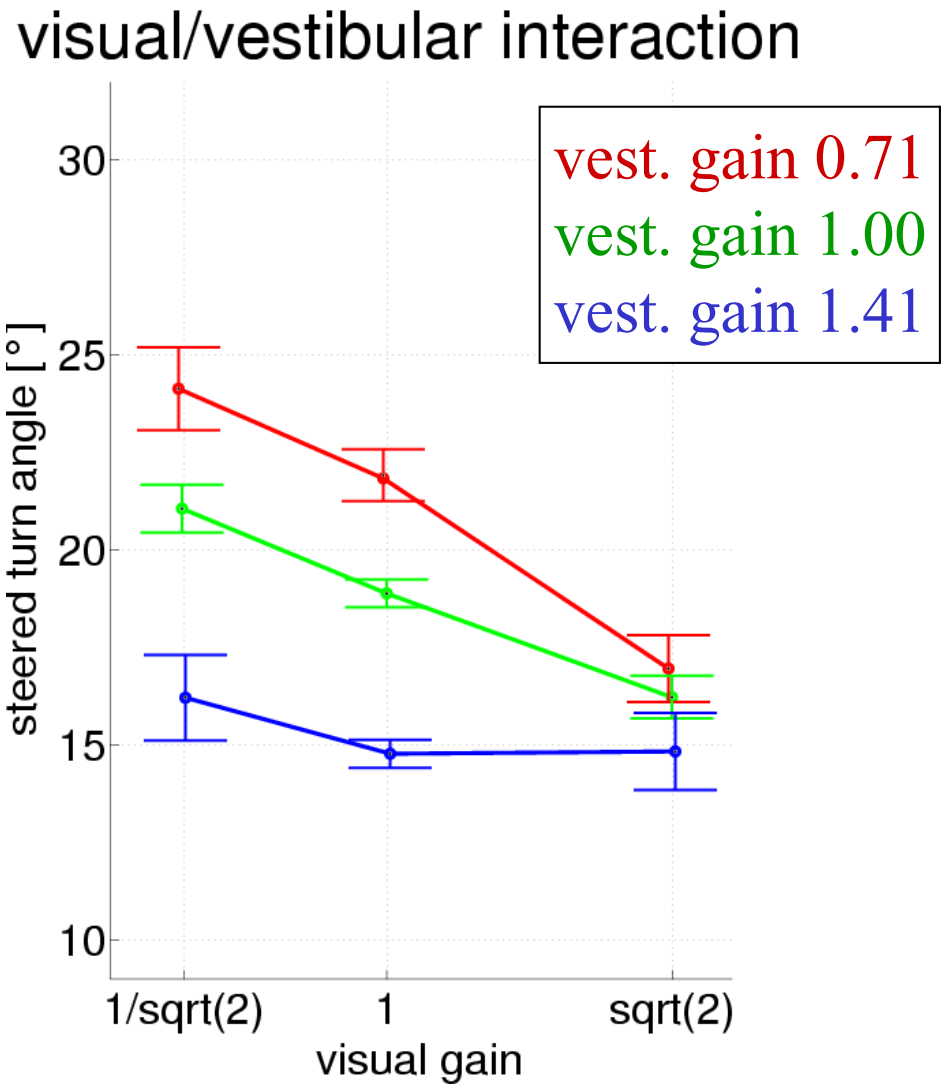


Expect: visual dominance



- Literature suggests visual dominance.
- Collapse data across turn angles → focus on gain factor effects.
- Stop earlier for higher gain.
- Stop later for lower gain.

Data: no visual dominance



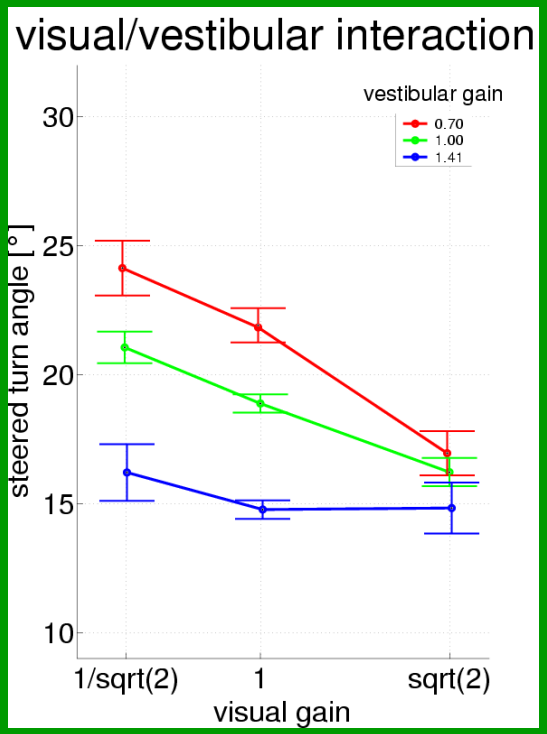
- Active and passive group show similar effects:
- Modality with higher gain has major effect.
- Complex integration of visual and vestibular turns.

Comparison:

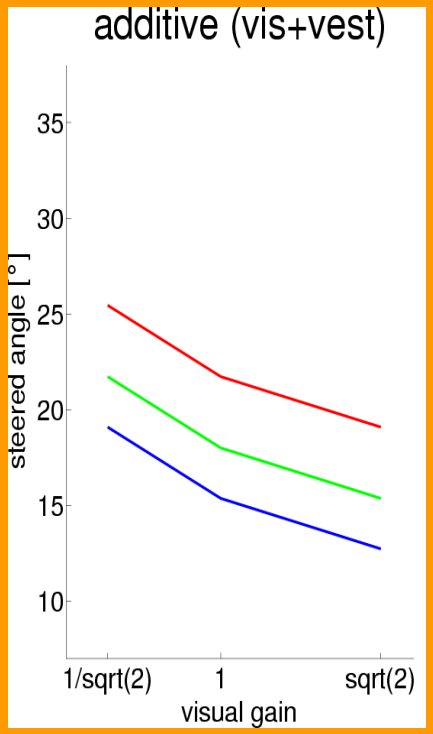
data - models

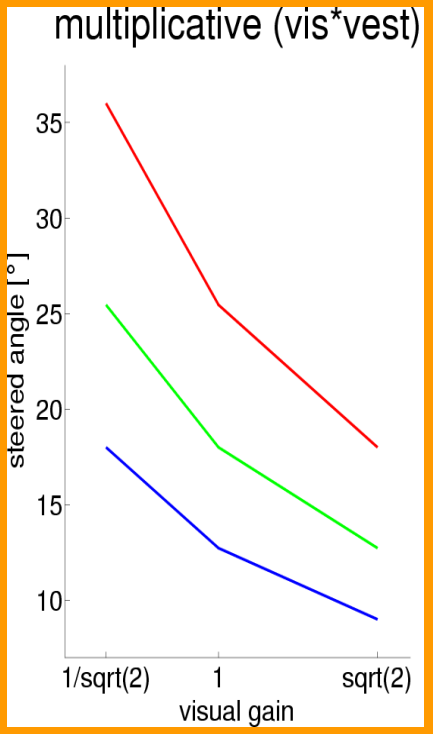
vest. gain 0.71
vest. gain 1.00
vest. gain 1.41

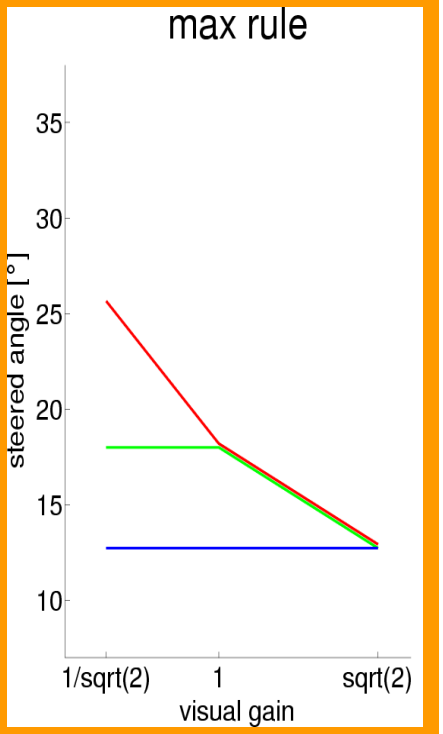
data



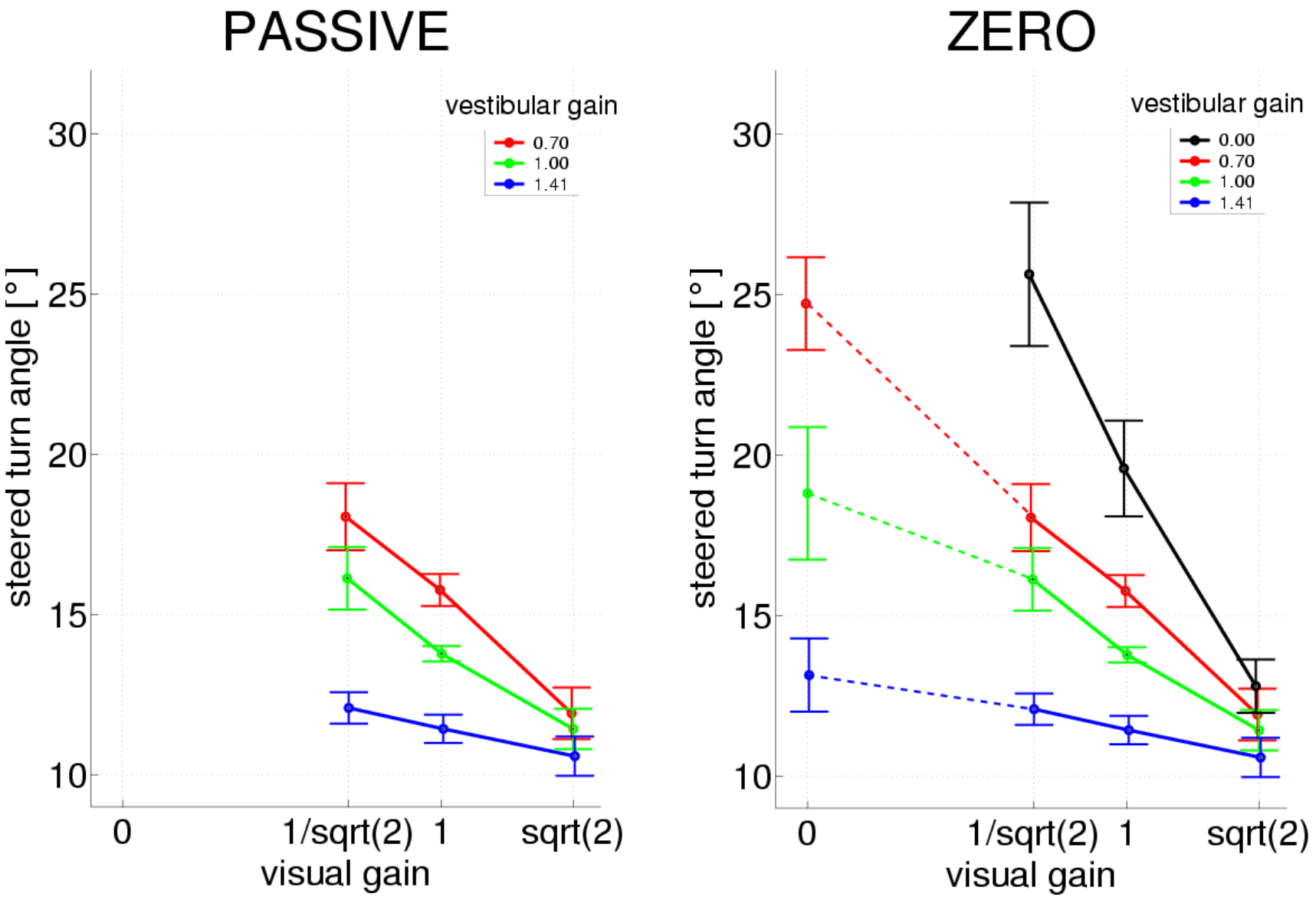
models







Gain factor ZERO



Results

- Subjects reproduced the learned turns.
- Gain factors were often not noticed, but still the distinction between the angles was made.
- Turns were executed until one modality reached the coded amplitude.

Conclusions

- **No** visual dominance, but **joint** storage for optic flow and vestibular turns.
- Cue integration may be explained by a ***max rule.***

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