Quantifying Neck Strain in HMD

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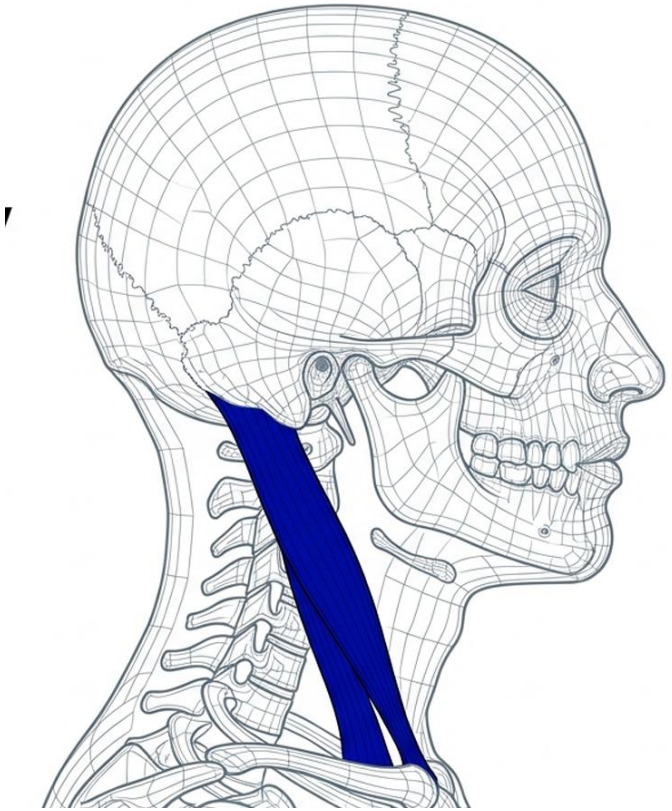

The Weight of the Virtual World

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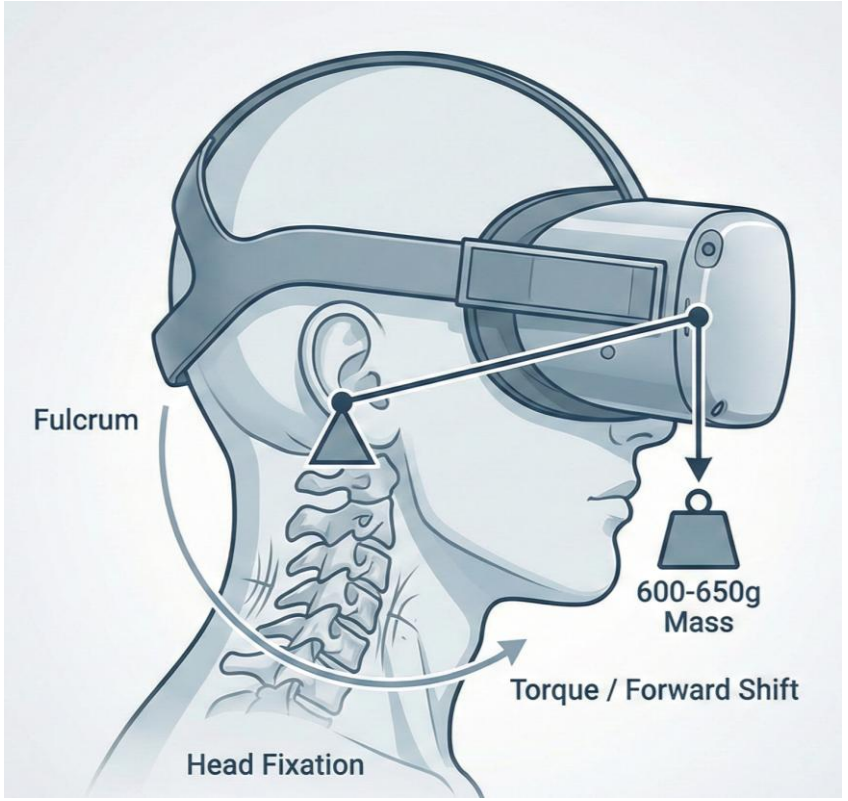
- **The Load**: add 600-650g of mass.
- **The Shift**: shifts the centre of gravity forward
- **Head Fixation**: holding the head still is often more fatiguing
- Limiting XR usage



Measurement

N=15 Participants	**67** Distinct Head Poses
30 Seconds per Pose	**±80° Yaw / ±50° Pitch**

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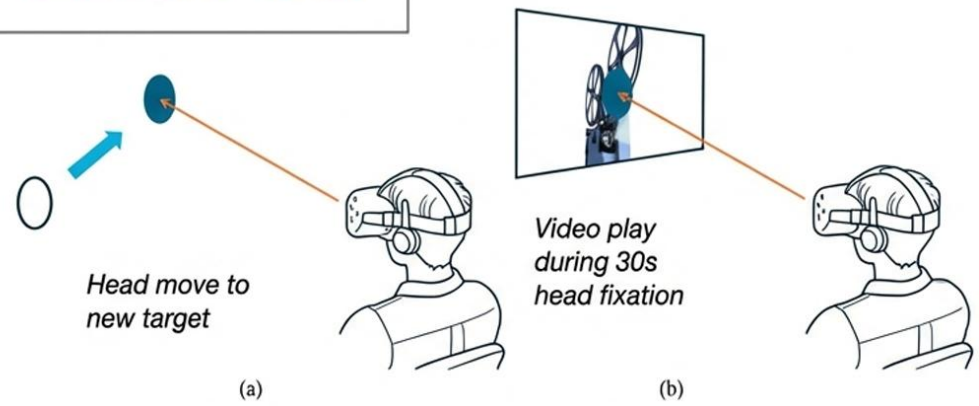
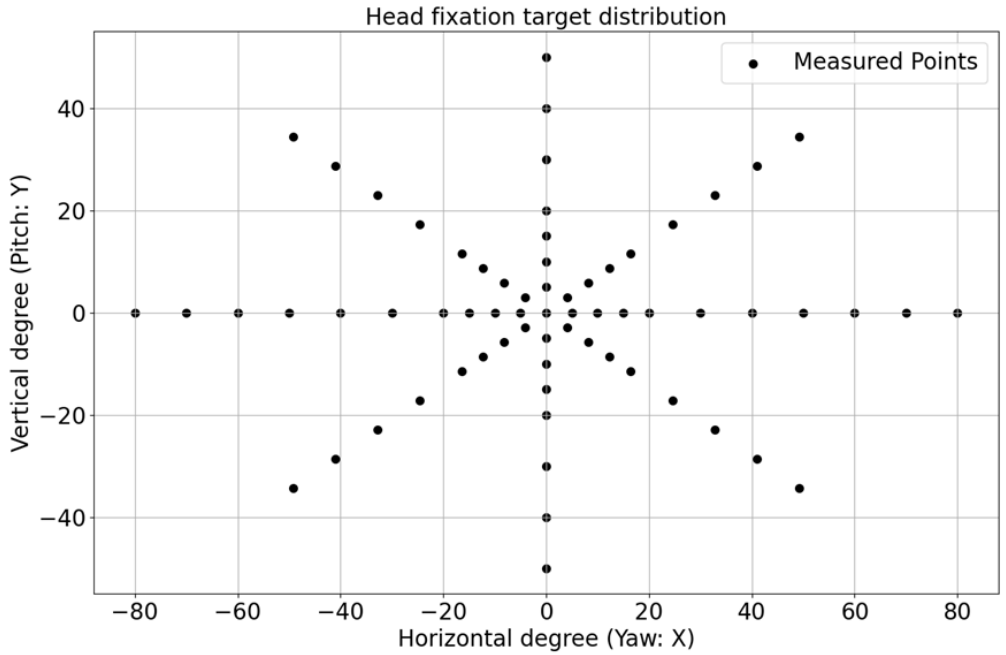
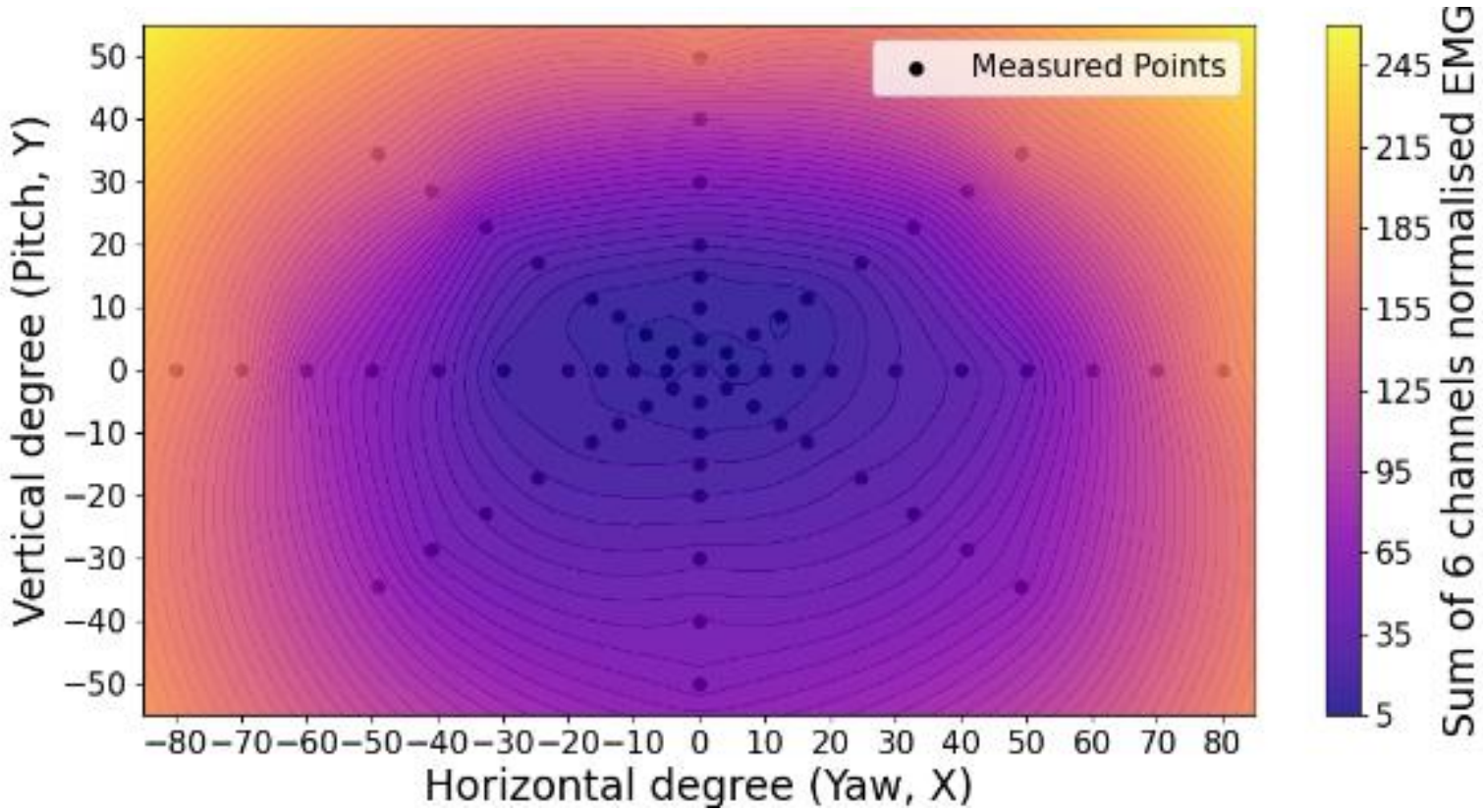
- Methodology: Surface Electromyography (SEMG) sensors placed on Sternocleidomastoid (SCM), Splenius Capitis (SPL), and Extensor Group (EXT).
- N=15 participants
- 30s per pose





Results: The comfort Ellipse

- The cost of interaction rises sharply as the user leaves the central “sweet spot” (approx. +30° Horizontal).
- Note the shape is elliptical, not circular.



The Asymmetry of Vertical Gaze

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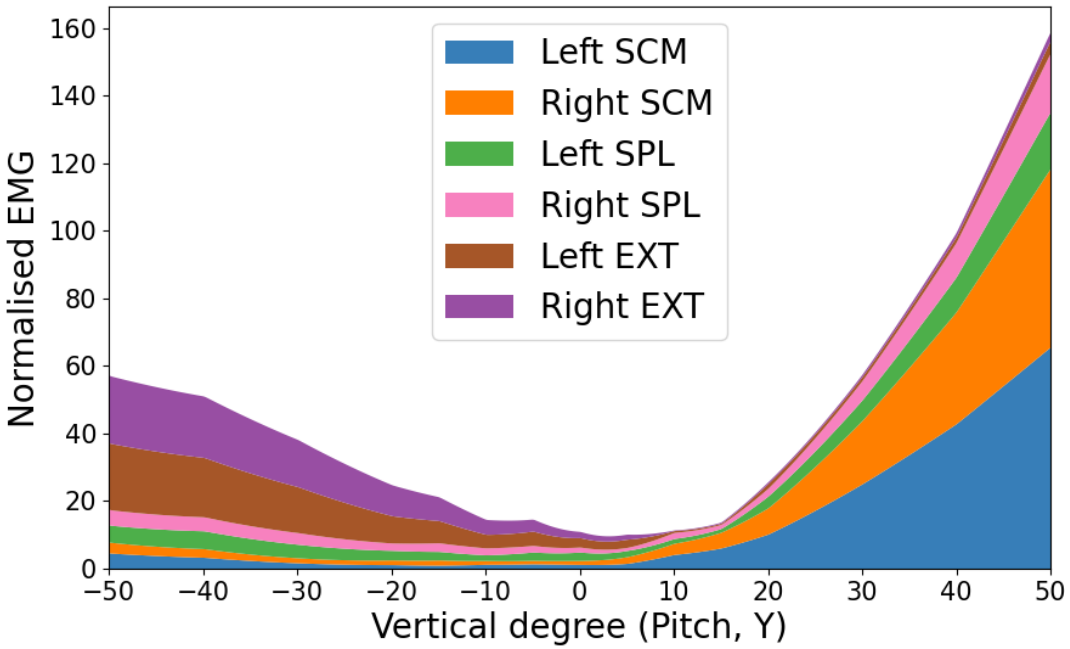
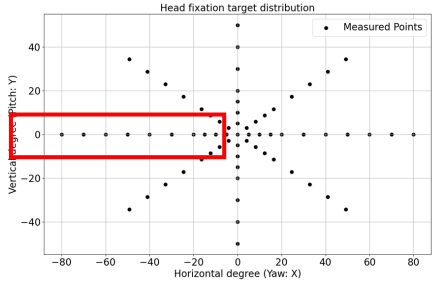
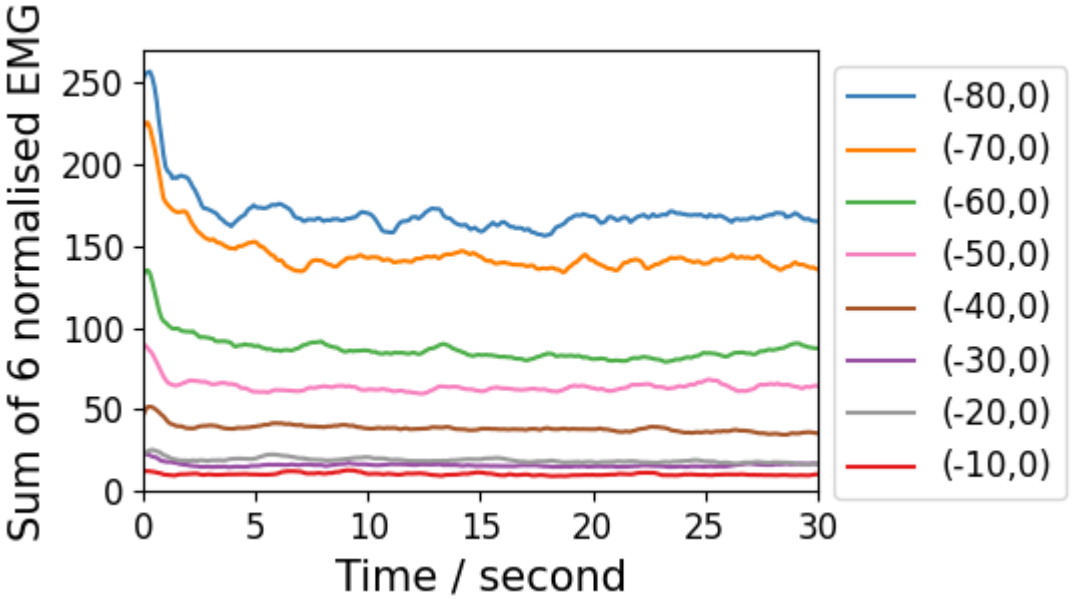
- Looking Down (Flexion): Muscle activity remains relatively low.
- Looking Up (Extension): Muscle activity rises sharply when pitch >15. The ‘Up’ penalty is significant.



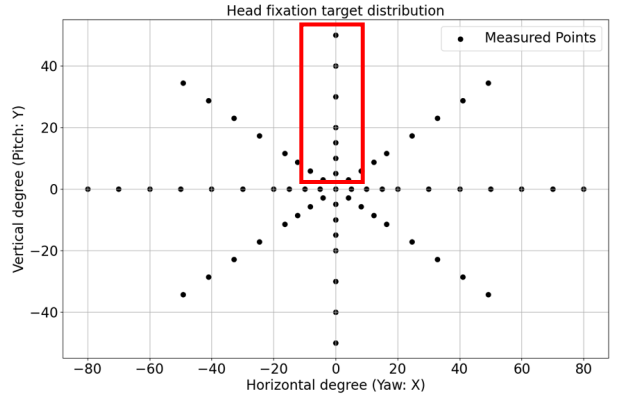
Temporal dynamics of muscle activity



- Left
- A decrease in the beginning of head fixation
- Right direction same

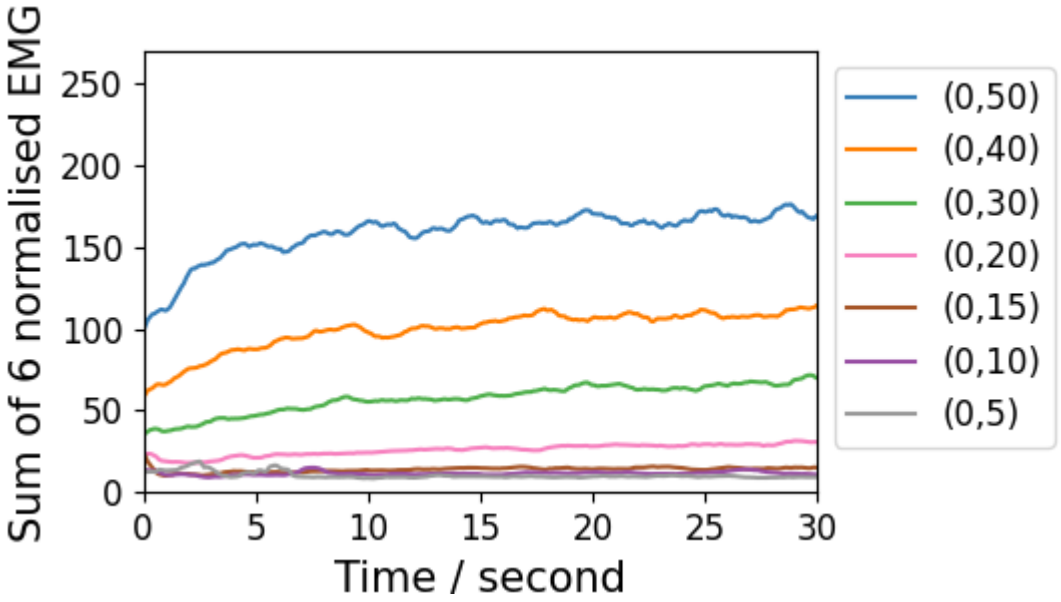


Temporal dynamics of muscle activity



- Up

- An increase at the beginning of head fixation



The Torso Compensator

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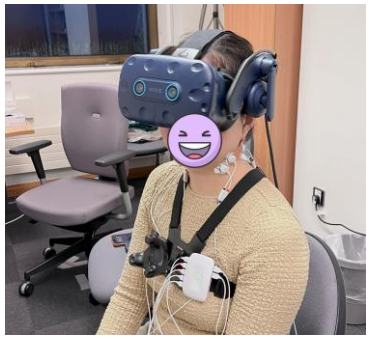
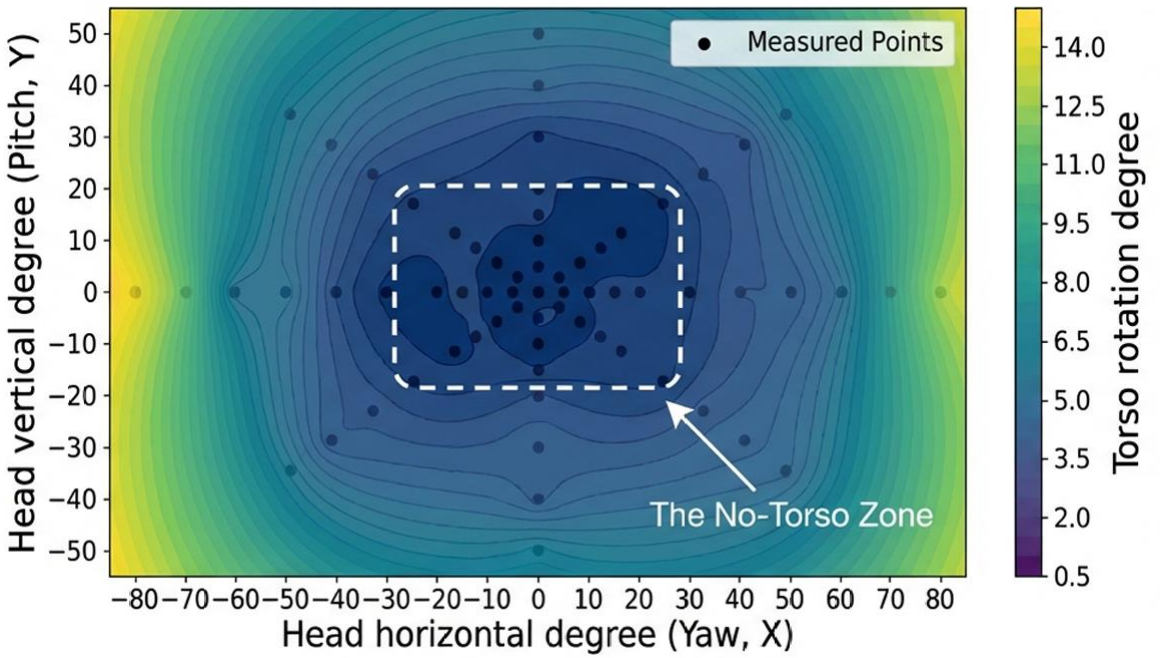
Insight: Users rotate their torsos to save their necks

Correlation: Neck EMG vs Torso rotation, r= 0.984.

Proxy: Torso rotation might serve as a proxy for neck discomfort



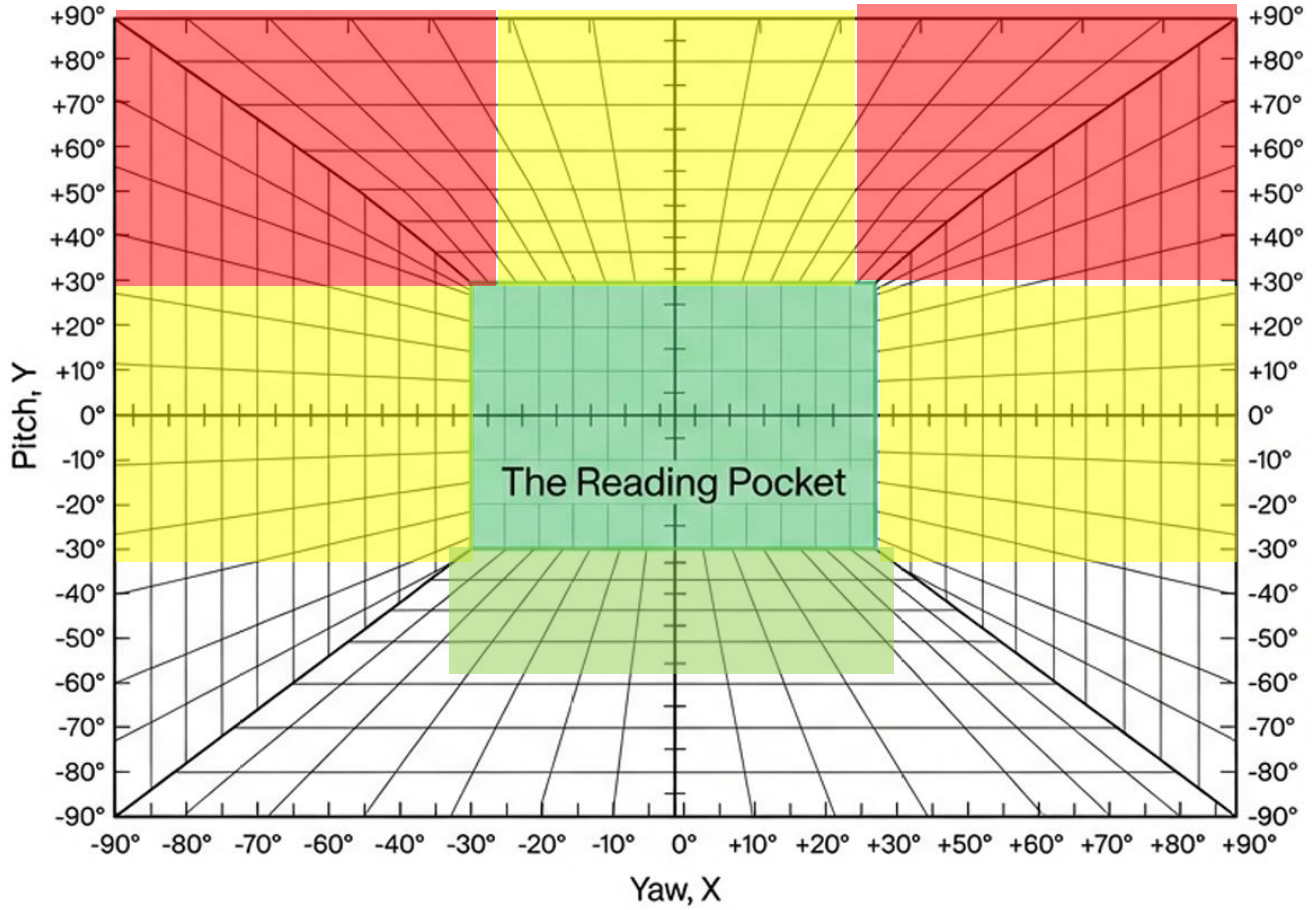


Interaction UI placement Implication

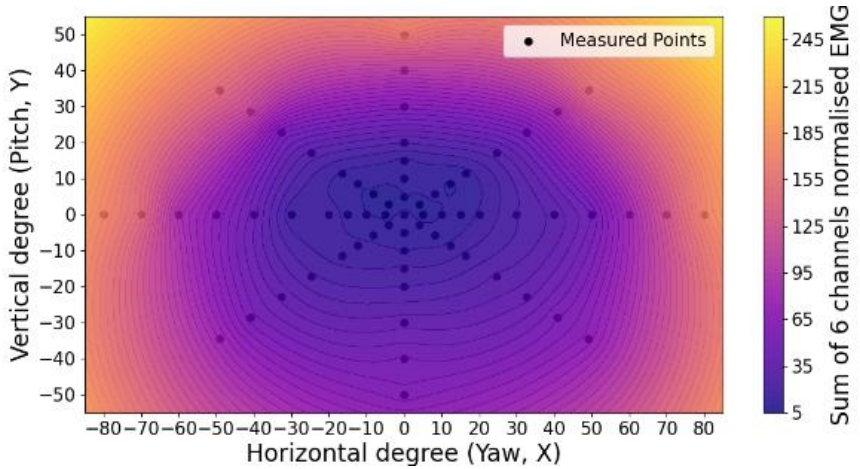
Green zone: long time

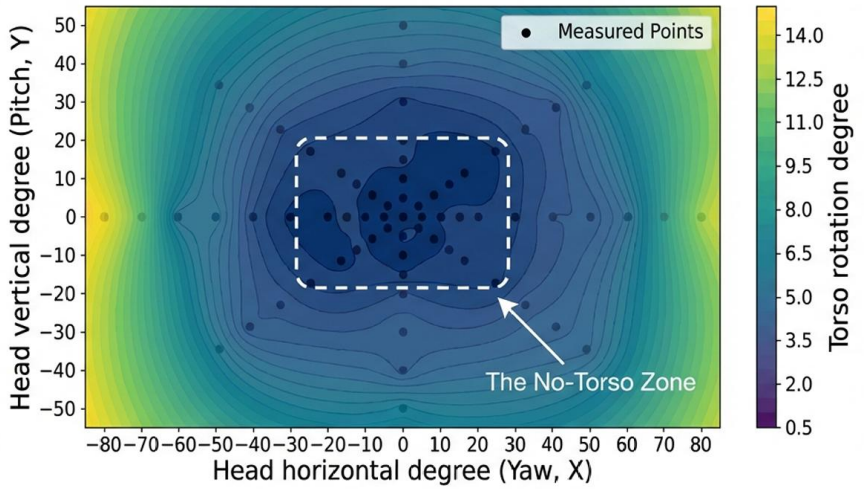
Amber zone: only shorten interaction

Red zone: avoid or just a glance

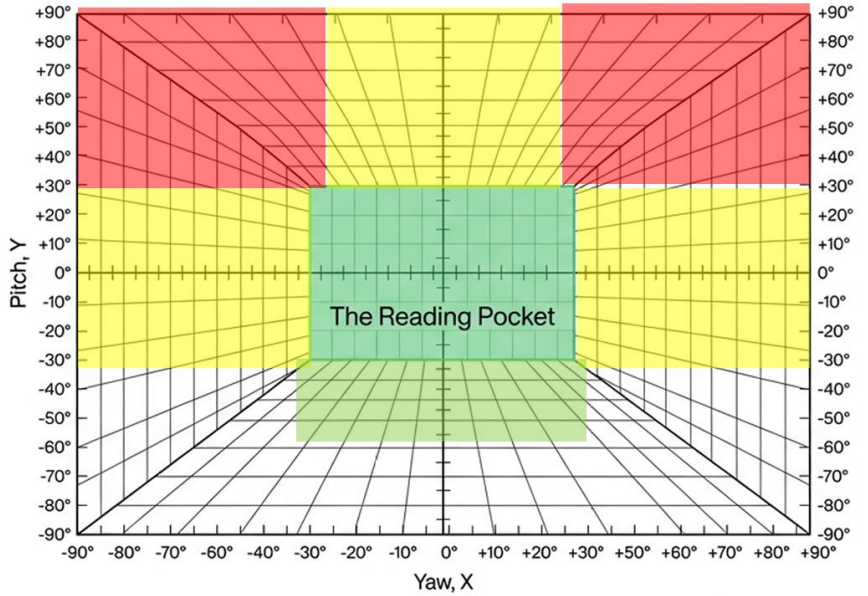


Thanks for Joining





- Neck Strain Heatmap
- Torso rotation might serve as a proxy for neck discomfort
- UI placement Implication



Li, G., Weidner, F., Hu, J., and Gellersen, H. (2025). Quantifying Neck Muscle Activity During Head Fixation in VR. Frontiers in Virtual Reality, 6, 1682866.