Perceptual Tuning to Angular Momentum in Gyroscopes

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Background

Gyroscopes possess novel properties for wielding -- they are difficult to manually manipulate due to their reactive forces. However, these forces are lawful:

- Reactive forces occur at a right angle to the input force (applied by the hand of the wielder).
- Their magnitude is determined by two components:
  1. Angular velocity (Ω) of input torque
     - i.e., to what degree was the gyroscope's axis reoriented?
  2. Angular Momentum (L) of flywheel
     - i.e., what is the mass of the flywheel, and how fast is it spinning?

we expect perceptual learning to occur through repeated wielding of a gyroscope device.

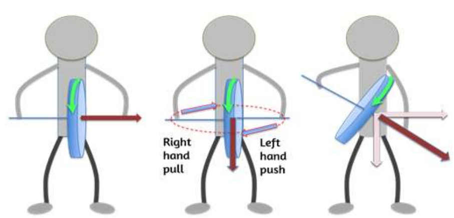
Reactive forces occur orthogonally to the input force (applied by the hand of the wielder)

$$\tau_{(reaction)} = \Omega \times L$$

.

- Their magnitude is determined by two components:
  1. Angular velocity (Ω) of input torque
     - i.e., to what degree was the gyroscope's axis reoriented?
  2. Angular Momentum (L)
     - i.e., what is the mass of the flywheel, and how fast is it spinning?

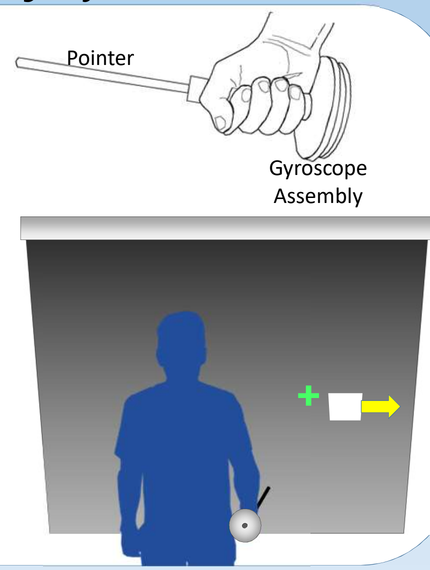
Gyroscopic Reactive Forces (GRFs)



Reactive forces redirect forces imposed by the wielder. However, as these forces are lawful, we expect some degree of **perceptual learning** to occur through repeated wielding of a gyroscope device. What form will this learning take?

- Retuning: Adapting to GRFs is accompanied by a learning aftereffect (in the opposite direction when the forces are removed.
- New Mental Representation: Participant able to instantly revert to peak performance after GRF removed (no aftereffect).

Procedure

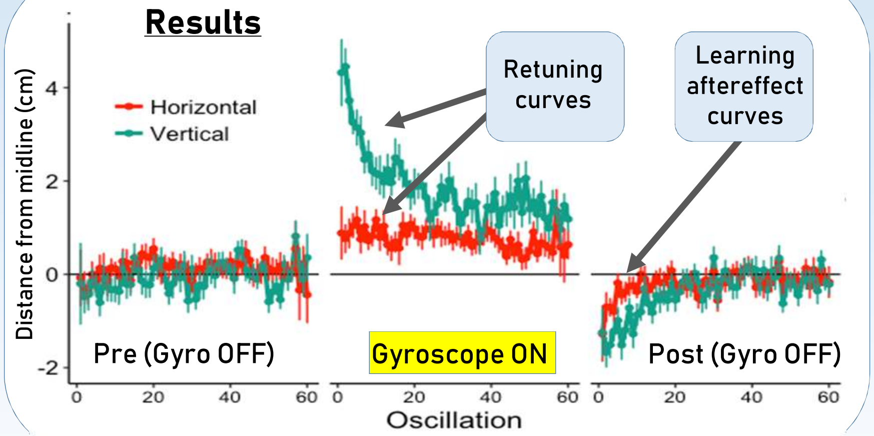


- Participant faces projection screen holding **gyroscope pointer**
- **Green cross** indicates heading of pointer
- Participant uses pointer to track **oscillating white square.**

Order of trials:

1. **Pre (Gyroscope OFF)**
2. **Gyroscope ON**
3. **Post (Gyroscope OFF)**

Results



Summary of findings

- Participants showed a steady improvement as the experimental condition progressed.
- Participants also showed a **retuning curve** when the GRFs were removed.
  - Suggests **perceptual retuning** rather than use of a representational mental model.
- Performance in second trial did not reach that of the first trial
  - Lack of *complete* retuning
  - May be due to relative shortness of trial (2 min).
- Vertical condition significantly more difficult with GRFs
  - Participant stabilizes against gravity when wielding
  - In Vertical condition, GRFs are perpendicular to gravity vector
- Confirms gyroscopes cause a reorientation of the force field for wielding.

Significance

- First formal study of perception-action implications of Gyroscopic Reactive forces (GRFs)..
- Gyroscopes a sort of "haptic prism" in both theory and application
- Suggests applications of gyroscopes for haptic system similar to prism goggles for vision
  - Research
  - Rehabilitation (e.g., Spatial Neglect)

References

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2. Redding, G. M., Rossetti, Y., & Wallace, B. (2005). Applications of prism adaptation: a tutorial in theory and method. Neuroscience & Biobehavioral Reviews, 29(3), 431-444.
3. Rossetti, Y., Rode, G., Pisella, L., Farné, A., Li, L., Boisson, D., & Perenin, M. T. (1998). Prism adaptation to a rightward optical deviation rehabilitates left hemispatial neglect. Nature, 395(6698), 166.

An electronic version of this poster is available at:
https://trbrooks.github.io