# GRIP: Dexterous Manipulation in Microgravity

*Switch to Space - 3*

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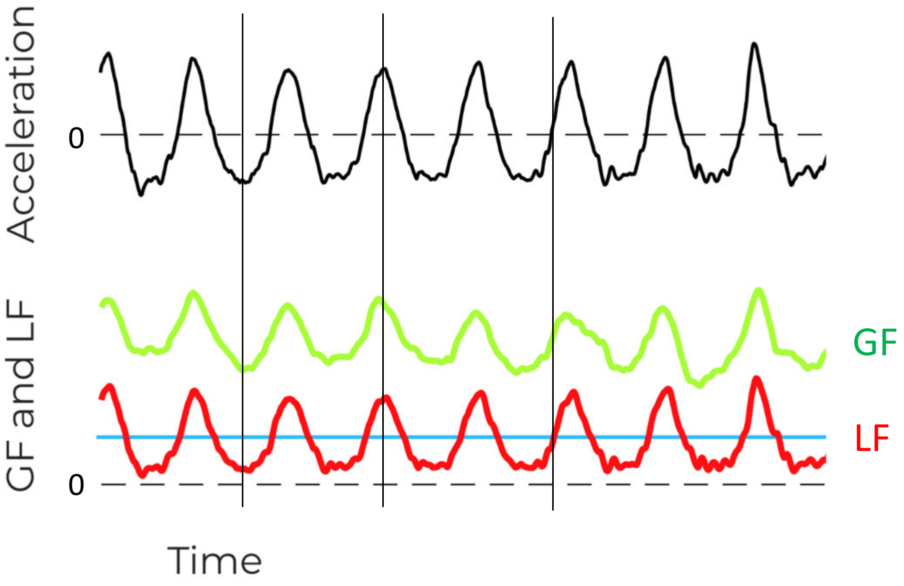
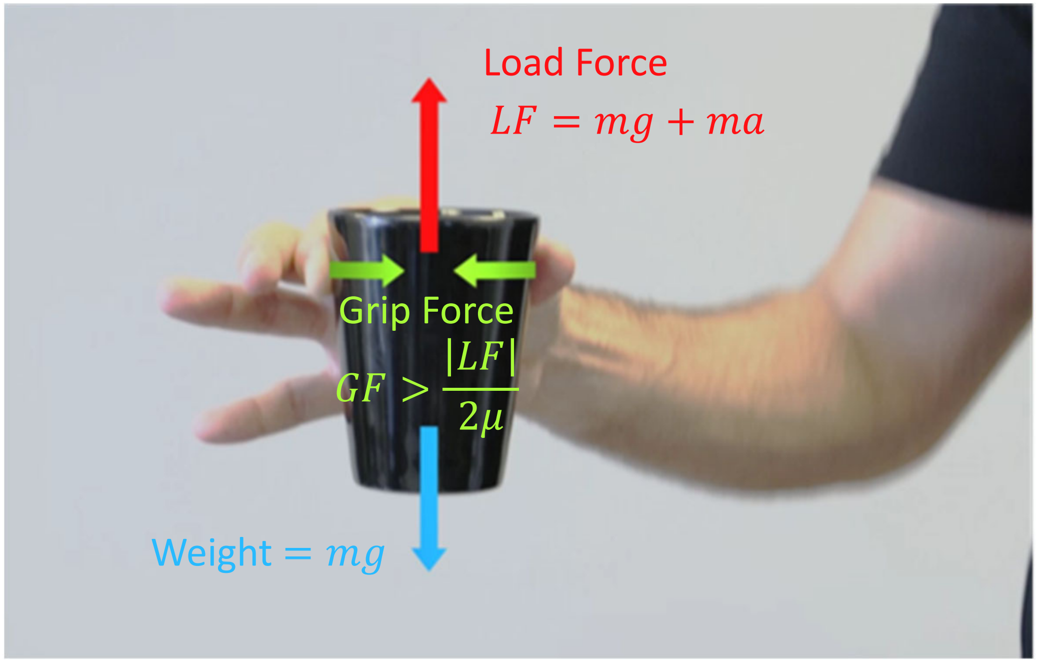
GRIP project: Jean-Louis Thonnard (PI) & Joseph McIntyre (co-PI)

# Science Background

GF and LF are tightly coupled during object manipulation



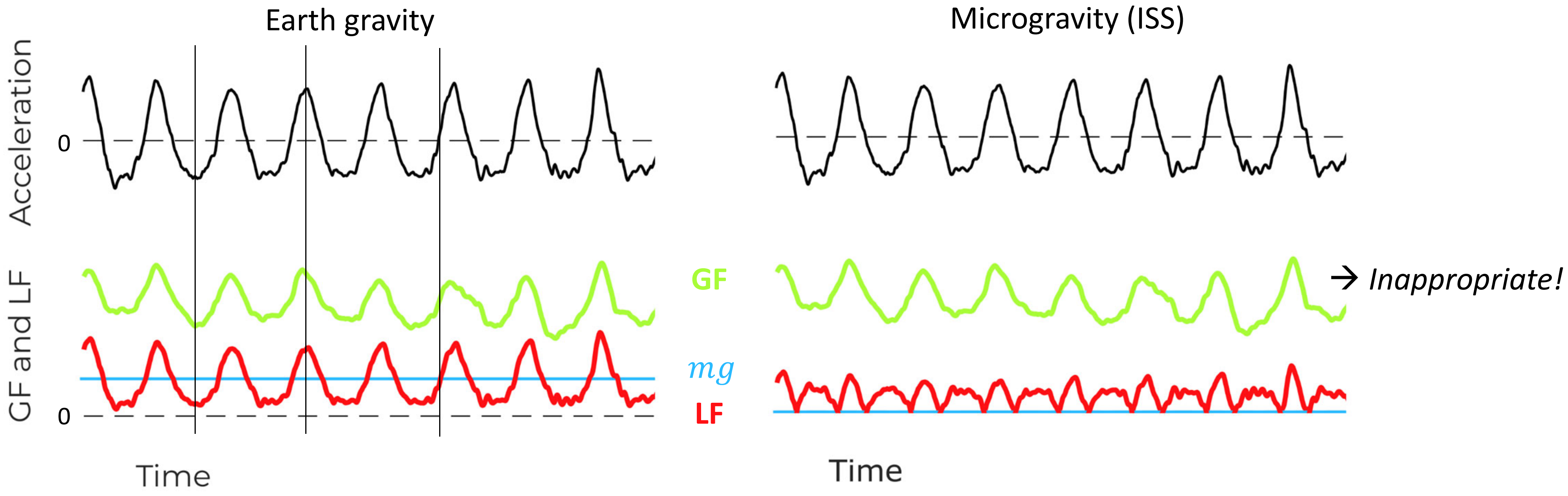


⇒ The brain predicts the consequences of arm movements

# Science Background

Remember: $GF > \frac{|LF|}{2\mu}$

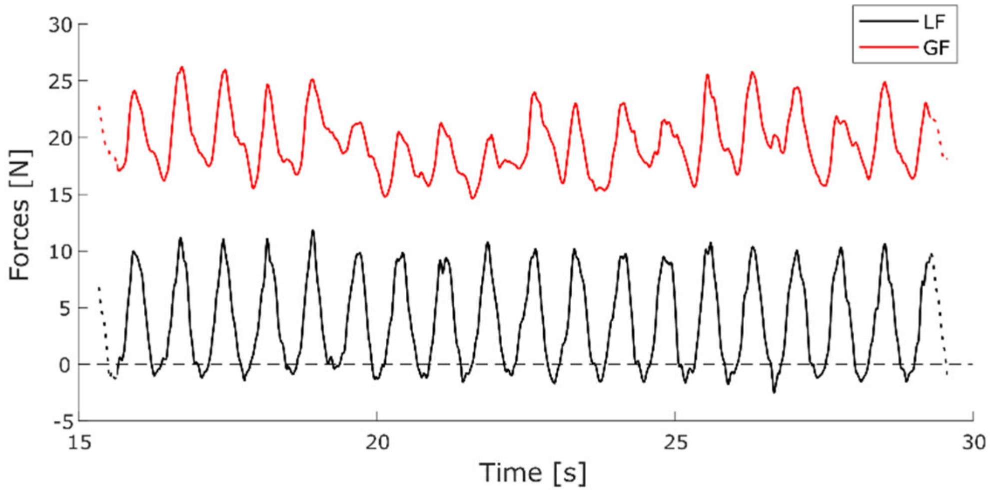
## Gravity matters !

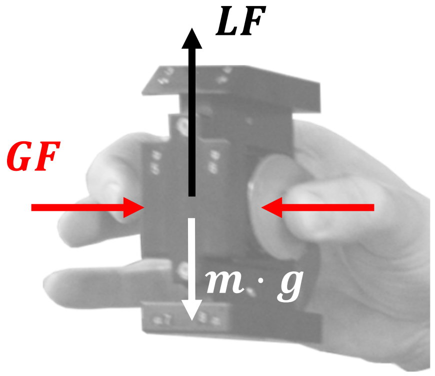


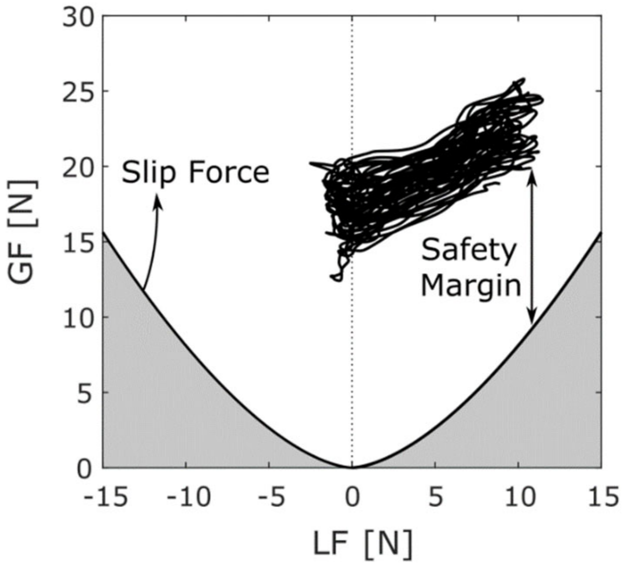
→ *Inappropriate!*

→ In microgravity, a new GF profile must be learned for an adequate force coordination

# Science Background







Load Force ($LF$): $LF = m \cdot (a + g)$

Slip Force ($SF$): $SF = \frac{LF}{2\mu}$

Grip Force ($GF$): $GF > SF \Rightarrow$ No slip

Safety Margin ($SM$):

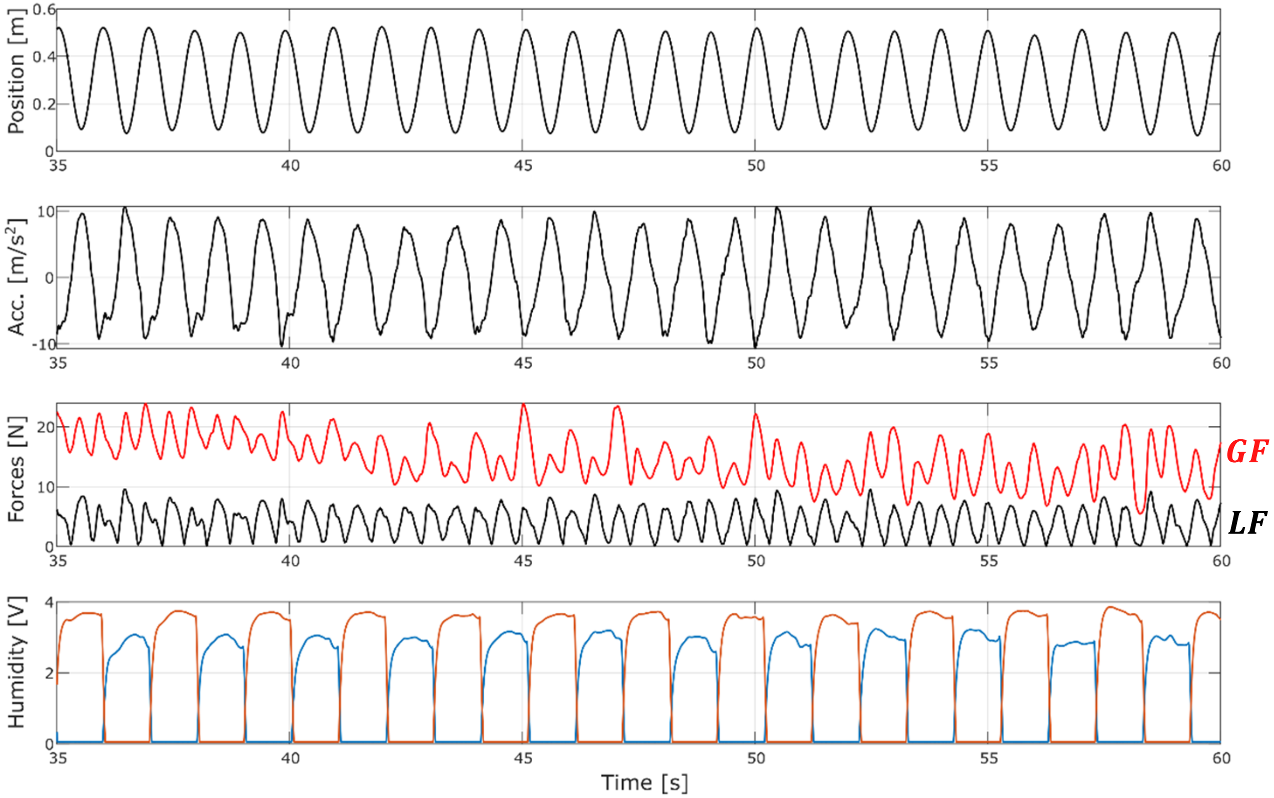
$$SM = \frac{GF - SF}{SF}$$

# Objectives of GRIP

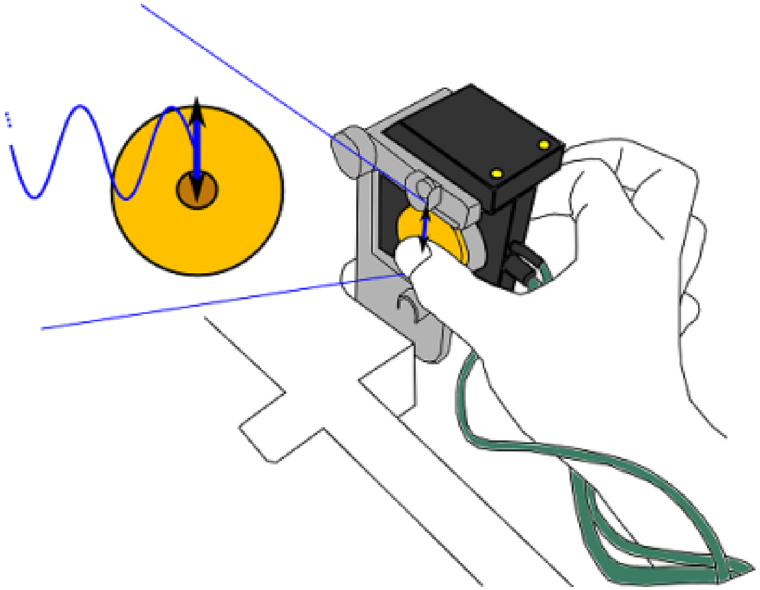
- **To challenge the ability of the brain to predict the consequences of motor commands**
  - How flexible are the internal models predicting the consequences of voluntary movements ?
  - How accurate is the brain in predicting LF variations when a parameter so ubiquitous as gravity is modified ?
- **To characterize the role of gravity in spatial orientation and sensorimotor optimization**
  - How do sensory and cognitive cues interact in defining a reference frame (e.g. “up” and “down”) for motor control ?
  - How, and how fast, are movement kinematics re-optimized to account for the novel environment dynamics ?

# Preliminary ISS Data

*Data from 2nd inflight session (Oscillation task -* $f = 1Hz, m = 800g$*)*



# Key role played by Friction

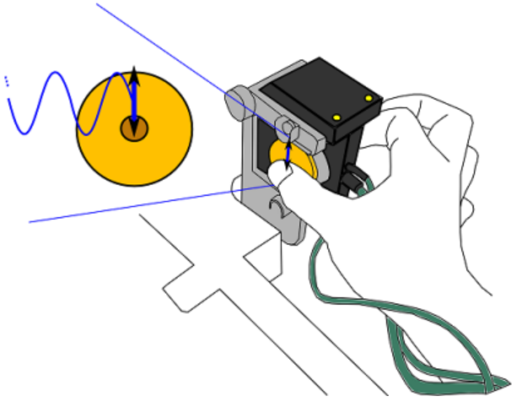


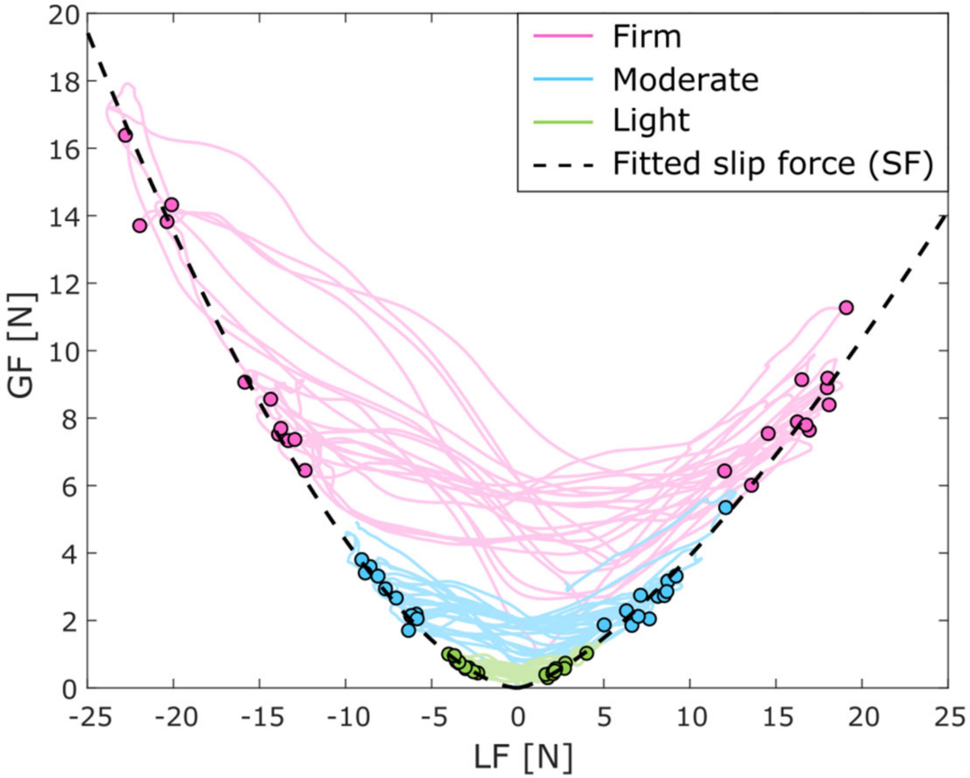
# Coefficient of Friction

**GOAL**

To estimate the **Slip Force (SF)**
=
minimum GF required to avoid slippage,

as a function of LF

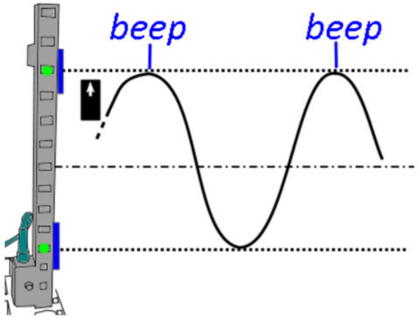




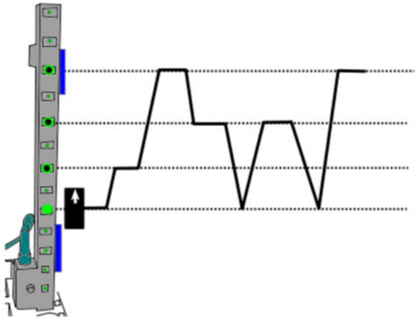
Slip Force $(SF)$: $SF = \frac{LF}{2\mu}$

# Four main Tasks

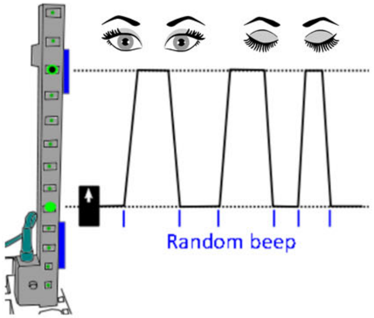
**OSCILLATIONS**



**TARGETED**

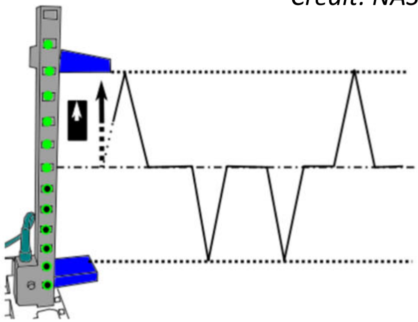


**DISCRETE**

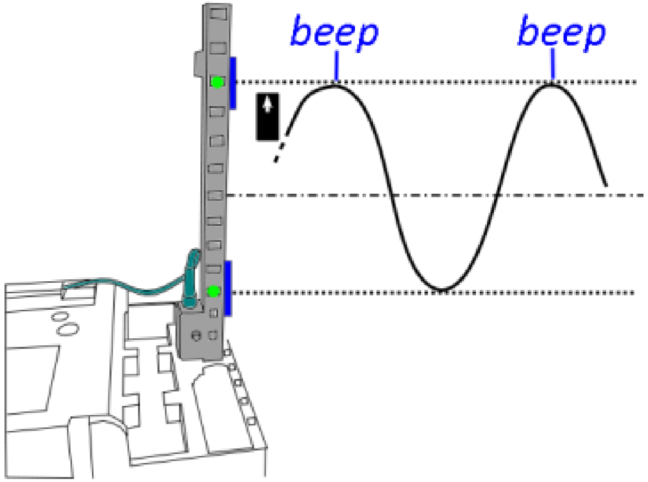


**COLLISIONS**

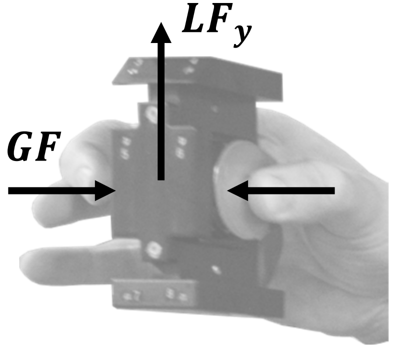
*Credit: NASA*



# Preliminary results: Oscillations



# Oscillations

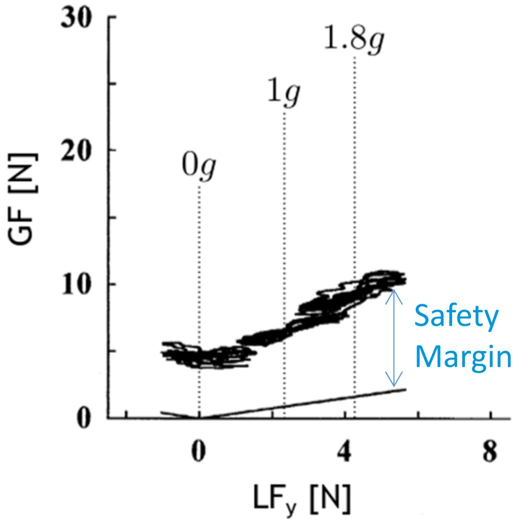


Rhythmic arm movements allow studying the tight synchrony between GF and LF

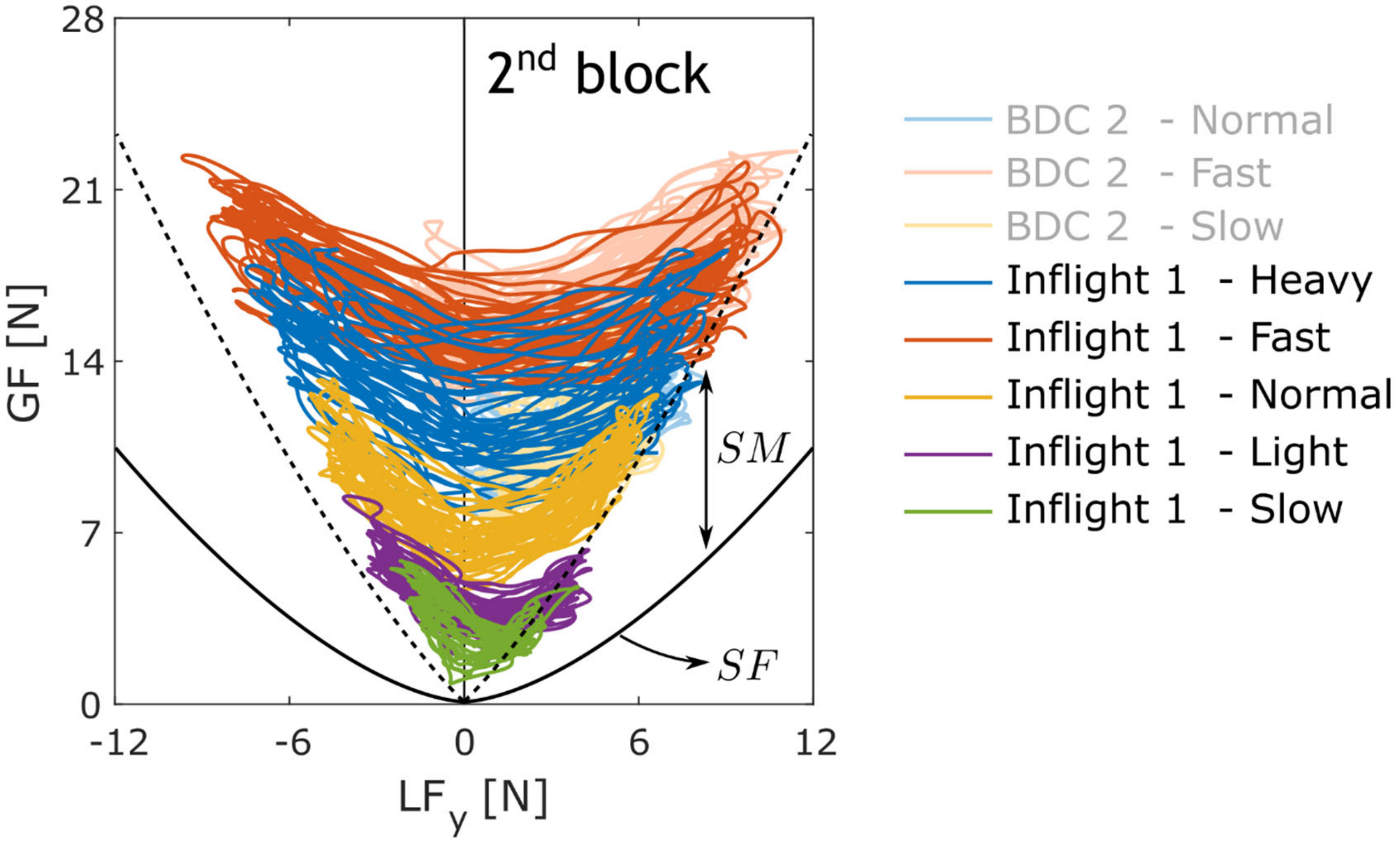
What is the influence of mass, frequency and gravity on how GF is modulated as a function of LF ?

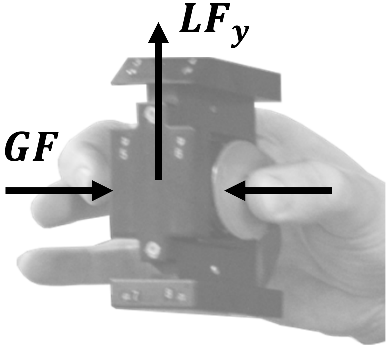
Is the safety margin more sensitive to one parameter than to others ?

*Augurelle et al. 2003*

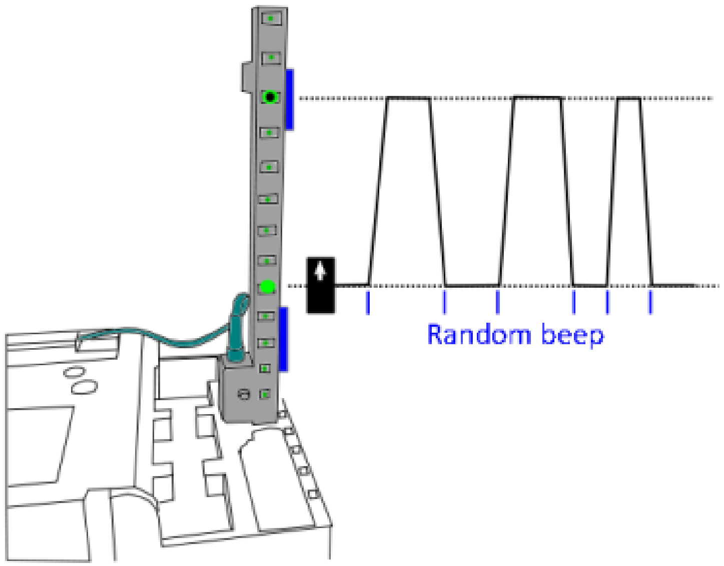


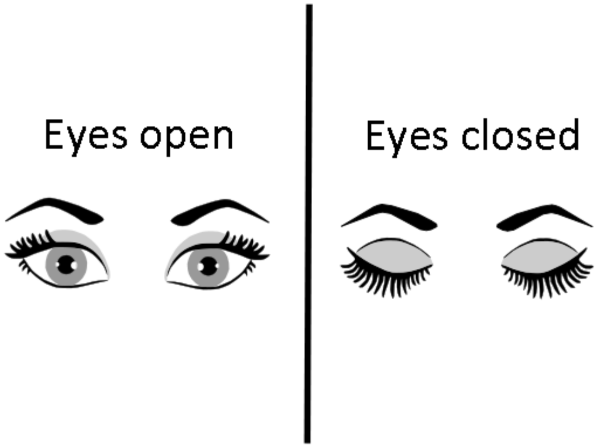
# Oscillations





# Preliminary results: Discrete movements





Eyes open

Eyes closed

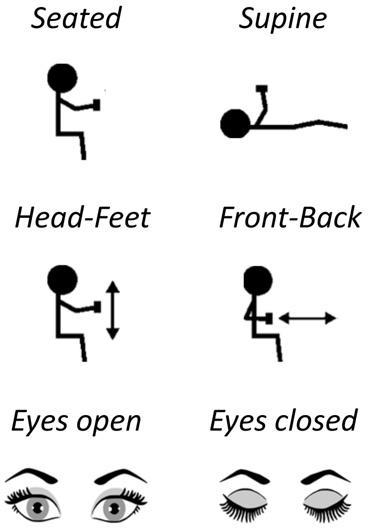
# Discrete movements

Seated

Supine

*Credit: NASA*

- Two body postures
- Two movement axes
- Two vision conditions



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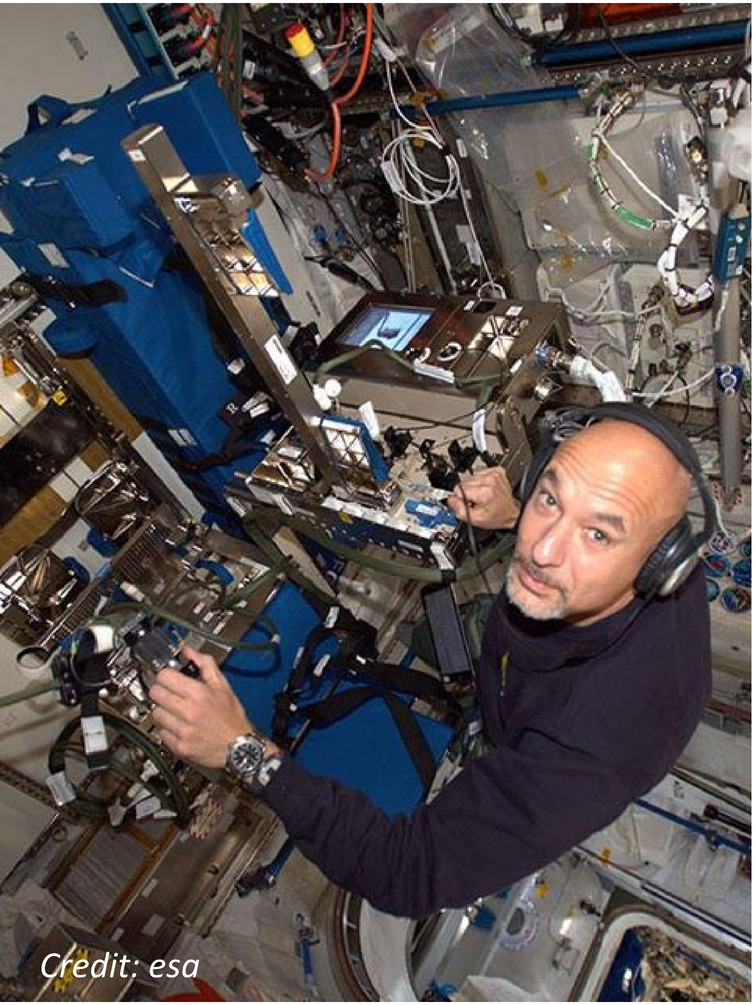
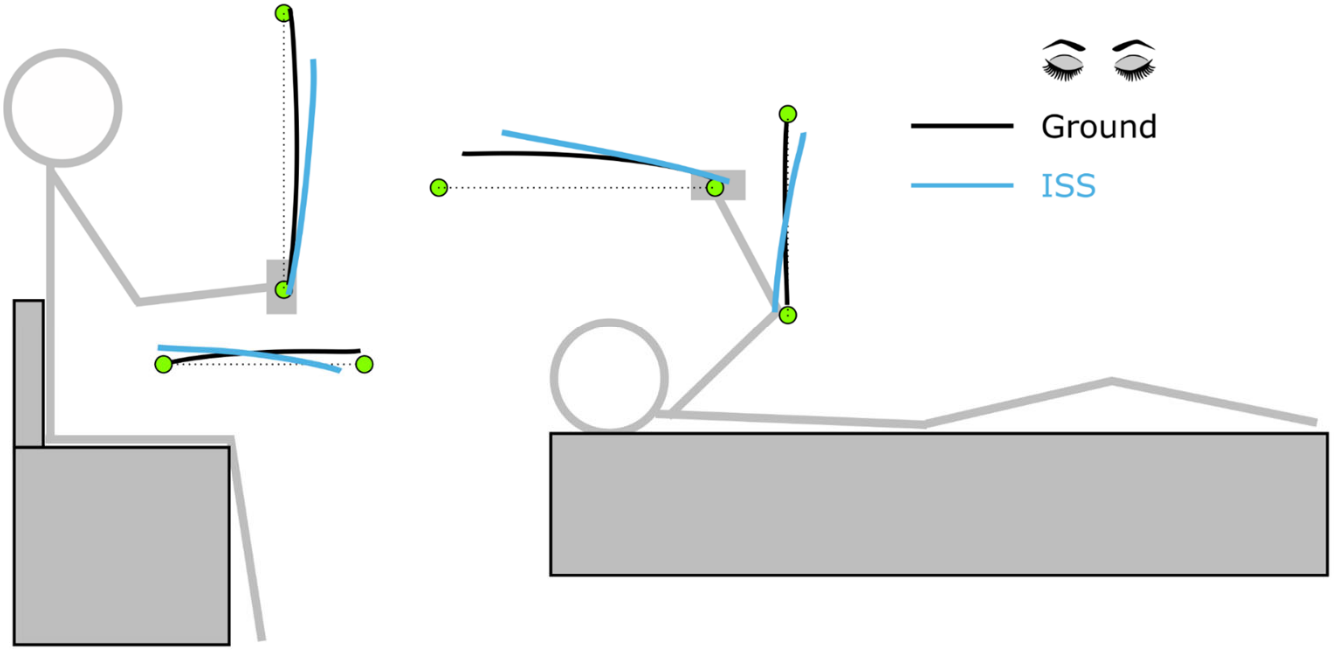


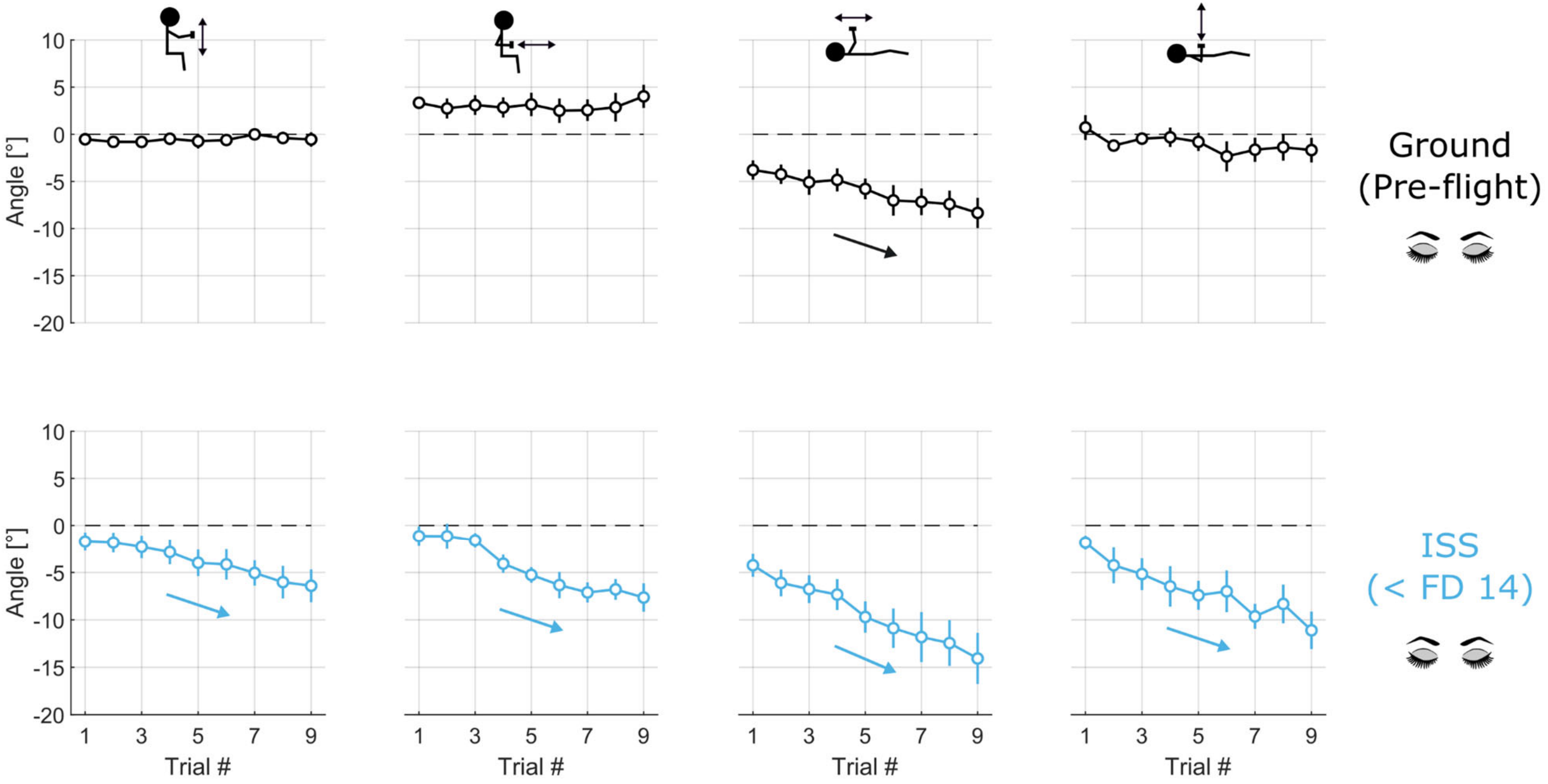
*Credit: esa*

Gravity: a central plumb-line for spatial orientation?



# Discrete movements

Hand-position drift in the absence of visual and gravitational cues (N=6)



# Conclusions

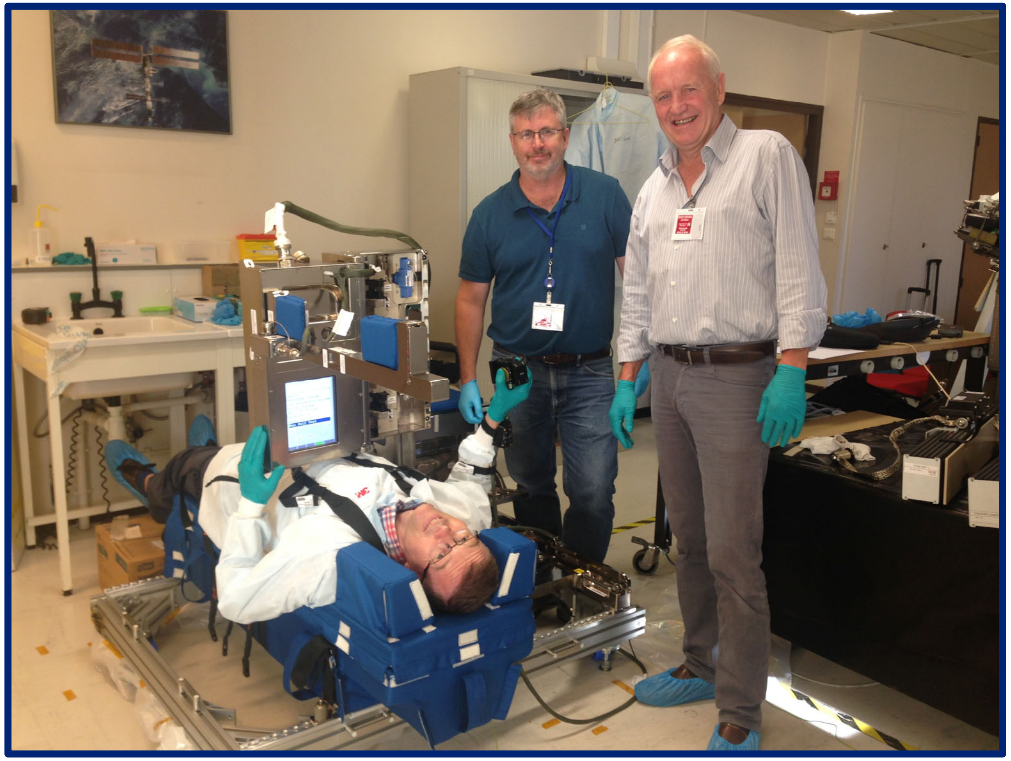
1. Brain predictive mechanisms are flexible: adaptation to microgravity is very efficient. Preliminary GRIP data from 6 astronaut subjects are very promising.

2. Preliminary ISS data from GRIP show that asymetries between « up » and « down » movements persist even after long exposure to microgravity.

3. Preliminary data from GRIP also demonstrate the importance of visual feedback in defining a reference frame for motor control.

4. GRIP data confirm the key role played by the coefficient of friction in the interpretation of dexterous manipulation on Earth and in microgravity.

# Thank you !



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