IMPACT OF OPERATOR' ORIENTATION AND MOVEMENT ON THEIR PERCEPTION AND CONTROL OF THE TELEOPERATED OBJECT

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Introduction

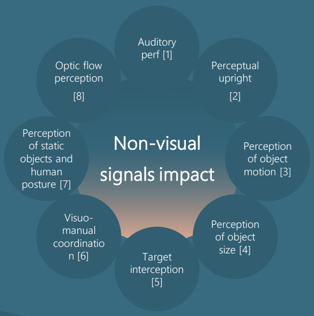
TELEOPERATION FROM A DYNAMIC ENVIRONMENT

Teleoperation requires the operator to possess an accurate **spatial perception of the environment** in which the robot is being controlled.

Spatial perception consist in the multi-sensory integration of the internal vestibular and somatosensory systems and external visual cues.

In a **dynamic environment**, the operator receives signals from the vestibular and proprioceptive systems, informing them that they are tilted and/or in motion.

These non-visual signals indicating a change in gravity have been found to **impair essential visuomotor faculties** needed for effective teleoperation.



Non-visual signals impact

Auditory perf [1]

Perceptual upright [2]

Perception of object motion [3]

Perception of object size [4]

Target interception [5]

Visuo-manual coordination [6]

Perception of static objects and human posture [7]

Optic flow perception [8]

Could an operator's body orientation and movement impact their teleoperation performance?

Could spatially incongruent movements with those of the robot further impact performance?

If so, could different types of visualization interfaces mitigate these effects?

Conclusion & Perspectives

INCONGRUENT MOVEMENTS FURHTER IMPACT PERFORMANCE

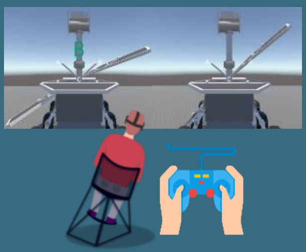
The body movements of an operator appears to further impair their **manual control** when spatially **incongruent** with the movement of the remotely controlled robot, in terms of *accuracy*, *precision*, and *response time* (Experiment 1).

OPERATORS MOTION IMPAIRS PERFORMANCE IN 1PP

The perspective from which an operator views the robot seems to affect teleoperation performance in navigation tasks. **The third-person perspective appears to be more suitable for teleoperation in dynamic environments**, even though performance is better in the first-person view when there is no movement (Experiment 2).

Perspective. In order to align with real-world conditions, future studies are planned to assess the impact of non-visual signals during the teleoperation of an actual drone within the ISAE-SUPAERO aviary. Drone piloting experts will be asked to perform a visual perception task and report impacts on a space station mockup in different body positions (lying down, standing).

Methods Experiment 1



On a **motion platform**, participants were asked to **tilt the panels of a rover in VR** while the chair was in **motion**.

Then to perceive the **panels orientation** while being **tilted**.

The **manual movements** to be performed could be **congruent** or **incongruent** with the **operator's body movements**.

N=54

Methods Experiment 2

On a **motion platform**, participants were asked to **pilot a drone in VR** while the chair was in **motion or stationary**.

The **chair movements** could be **congruent** or **incongruent** with the drone movements.

Participants could control the drone in different **perspectives** (1PP vs. 3PP) and **attitude display** (fixed-drone vs. fixed-horizon) types of visualizations.

N=11

Results Experiment 1

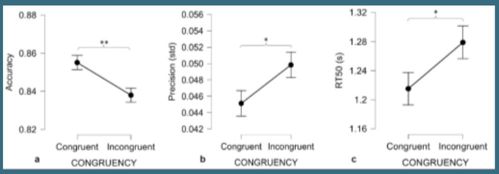
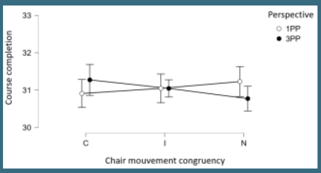


Fig 1. Effect of whole-body and manual control movements congruency on a accuracy ($F_{1,53}$ = 10.7, p = .002, η^2_p = .168), b precision (($F_{1,53}$ = 4.57 , p = .037, η^2_p = .079), and c response time ($F_{1,53}$ = 4, p = .049, η^2_p = .071). The accuracy corresponded to the normalized average angle of the panel during the last 5 seconds of the trial, i.e. 1 corresponds to the target angle. Precision corresponds to motor responses' standard deviation during manual control during the last 5 seconds of the trial. RT50 corresponds to the time to reach 50% of the final response angle. Error bars represent the standard errors (∗∗ p < .01,∗ p < .05).

Results Experiment 2



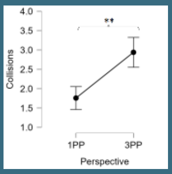
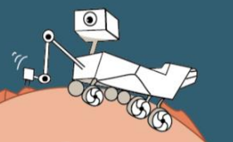


Fig 2. Interaction between perspective and congruency of chair and drone movements on course completions ($F_{1,10}$ = 3.7, p = .043, η^2_p = .003). The course completion correspond the number of times participants successfully navigated through the entire course, passing all the required elements, such as hoops and arches). **Fig 3. The impact of perspective on the incidence of participants' collisions.** ($F_{1,10}$ = 15.8, p = .003, η^2_p = .613). Error bars represent the standard errors (∗∗ p < .01).



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