



HAL
open science

Does a small perturbation created by an upper-limb exoskeleton impact our coordination in reaching tasks?

Océane Dubois, Agnès Roby-Brami, Ross Parry, Nathanael Jarrasse

► To cite this version:

Océane Dubois, Agnès Roby-Brami, Ross Parry, Nathanael Jarrasse. Does a small perturbation created by an upper-limb exoskeleton impact our coordination in reaching tasks?. Progress in Motor Control, Sep 2023, Rome, Italy. hal-04228833

HAL Id: hal-04228833

<https://hal.science/hal-04228833v1>

Submitted on 4 Oct 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

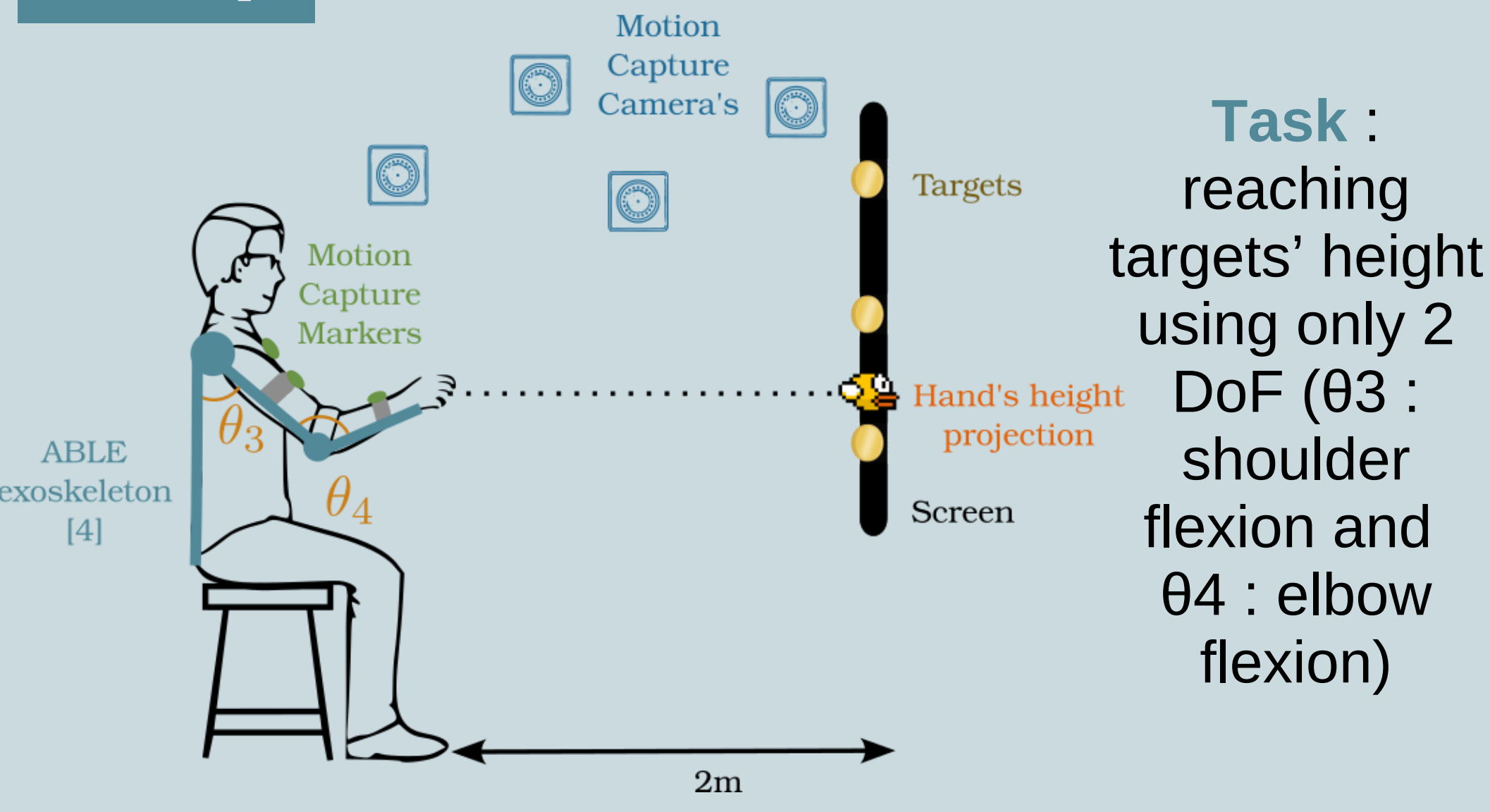
Does a small perturbation created by an upper-limb exoskeleton impact our coordination in reaching tasks ?

A low-magnitude perturbation applied by an exoskeleton at the joint level still alters joint coordination once the disturbance is removed, even though task performance is unchanged.

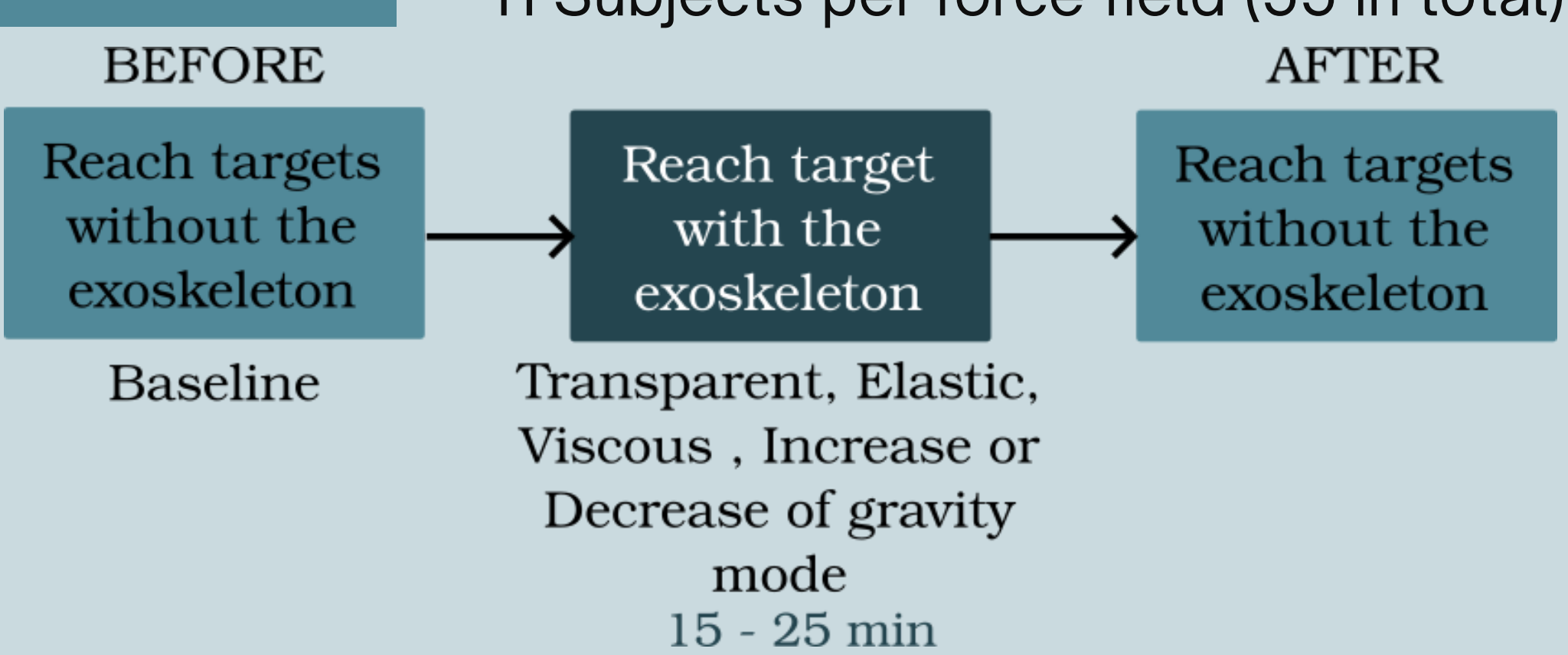
Océane Dubois
Agnès Roby-Brami
Ross Parry
Nathanaël Jarrassé

The impact of **perturbations** applied at the human end-effector level has been widely studied as well as the **learning process** which results from it [1]. However, the effect of **perturbations at the joint level** and the learning process related to it has been poorly investigated [2] [3]. Indeed, due to the redundancy of human limbs, perturbations at the joint level **do not necessarily affect the task** and therefore, the central nervous system might adapt differently. This study investigates **the impact of a low-amplitude joint-level perturbation on our coordination strategies** while performing a reaching task.

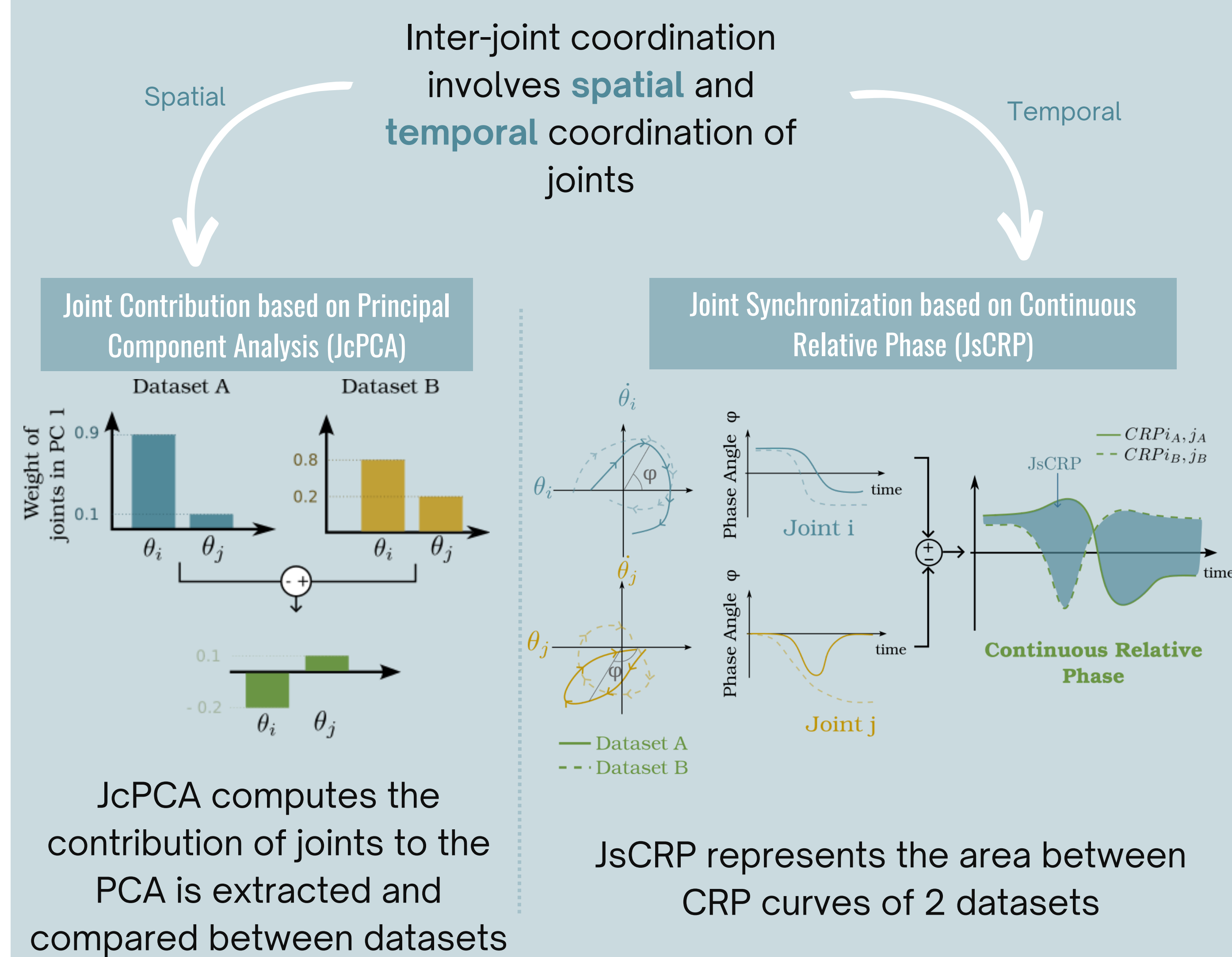
Set-up



Protocol



Metrics of inter-joint coordination [5]



Comparing movements before and after being exposed to the force field in the exoskeleton.

End effector and joints results

- No significant differences on the **end-effector** metric nor on **range of motions** of joints.
- Only the **Viscous** Force Field is statistically significant (*) for the **overshoot** metric and **joint range of motion 3**

	End-effec. distance (%)	Overshoot (%)	Maximum End-effec. velocity (%)	Task Time (%)	Time to maximum velocity (%)
Transp.	-0.1±0.16	-0.97±2.48	0.00±0.34	-0.05±0.23	-0.03±0.33
Elastic	-0.04±0.17	-0.20±0.74	0.10±0.46	-0.06±0.33	-0.06±0.28
Viscous	0.07±0.17	0.5±0.4*	0.01±0.51	-0.13±0.22	-0.16±0.35
Decr.	-0.15±0.18	-0.63±1.35	-0.17±0.63	-0.08±0.24	0.03±0.23
Incr.	-0.04±0.18	-0.23±1.47	-0.65±2.32	-0.01±0.18	0.06±0.18

	ROM 1 (%)	ROM 2 (%)	ROM 3 (%)	ROM 4 (%)
Transp.	-0.39±0.87	-0.03±0.13	-0.20±0.55	0.08±0.31
Elastic	-0.48±0.95	-0.02±0.21	0.15±0.23	-0.05±0.38
Viscous	0.09±0.37	-0.18±0.33	0.40±0.27*	-0.45±0.57
Decr.	-0.57±0.81	-0.05±0.31	-0.18±0.44	0.00±0.36
Incr.	-1.28±2.11	-0.06±0.47	0.10±0.56	-0.18±0.75

FORCE FIELDS HAVE NO IMPACT ON THE TASK'S PERFORMANCE ...

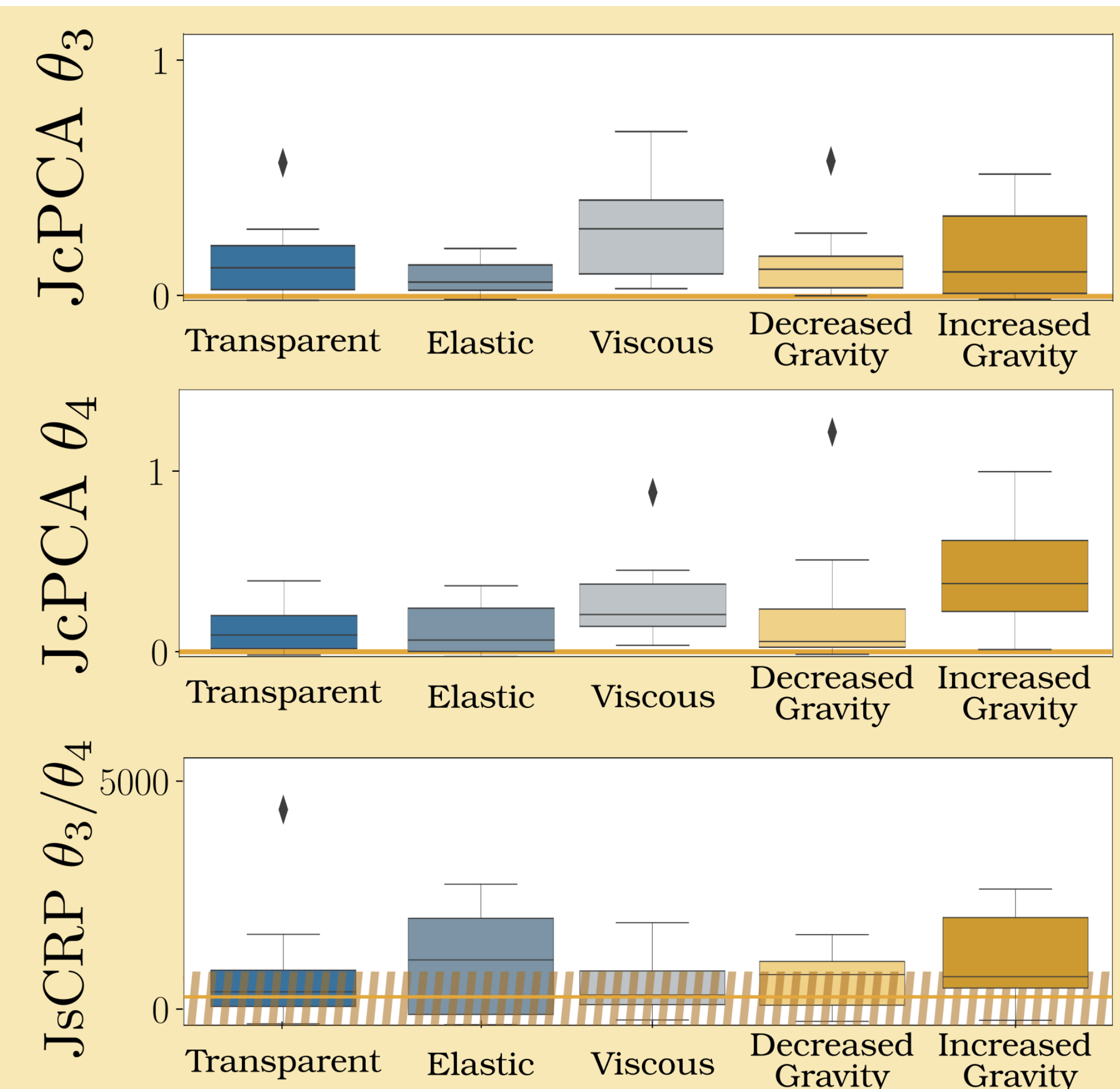
Inter-joint coordination results

	Transp.	Elastic	Viscous	Decr.	Incr.
JcPCA θ_3	8	7	10	11	8
JcPCA θ_4	6	8	9	6	9
JsCRP θ_3/θ_4	7	7	4	7	9

Table 1: Number of participants (out of 11 per group) that modified their coordination strategy to each force field

- Viscous** and **Decrease of gravity** are the force field with the most important effect on θ_3 contribution.
- Increase of gravity** is the field that creates the greater change of inter-joint coordination both for spatial and temporal organization of joints.
- Elastic** force field impacts essentially the joint synchronization
- Even the **Transparent** force field affects most of the subjects.

... BUT THE COORDINATION STRATEGIES CHANGED !



- The crosshatching area is the natural variability of all subject (i.e. their variability within the Natural Before Exposition Condition)

Conclusion & Discussion

SHORT EXPOSITION OF LOW-MAGNITUDE FORCE FIELD IMPACTED COORDINATION STRATEGIES !

- There is **no differences** in the task performance before and after exposition to the force field regarding the **end-effector** and the joints ROM.
- The coordination strategies is **most impacted** by the **viscous** force field. The **Increase of gravity** force field created **greater change in the coordination strategies** for more than half of the subjects.
- Long term effect** of those force fields should be investigated.
- The **evolution of the coordination strategy** during the **exposition** to the force field could be explored.
- The **exploration of the individual characteristics** (fatigue generated, vigor, etc.) could explain why did some subjects adapt or not to the force fields

References

- [1] Shadmehr, R., & Mussa-ivaldi, F. A. (1994). Adaptive Task of Dynamics during Learning of a Motor Task. The Journal of Neuroscience: The Official Journal of the Society for Neuroscience, 14(5), 3208-3224.
- [2] Mistry, M., Mohajerian, P., & Schaal, S. (2005). Arm movement experiments with joint space force fields using an exoskeleton robot. Proceedings of the 2005 IEEE 9th International Conference on Rehabilitation Robotics, 2005
- [3] Tomita, Y., Rodrigues, M. R. M., & Levin, M. F. (2017). Upper Limb Coordination in Individuals With Stroke: Poorly Defined and Poorly Quantified. Neurorehabilitation and Neural Repair, 31(10-11), 885-897
- [4] Garrec, P., Fricconneau, Y., Méasson et al. (2008) ABLEx, an Innovative Transparent Exoskeleton for the Upper-Limb. International Conference on Intelligent Robots and Systems, INRIA.
- [5] In press : Dubois, O., Roby-Brami, A., Parry, R., Khoramshahi, M., & Jarrassé, N. (2023). A guide to inter-joint coordination characterization for discrete movements: A comparative study.