

# PNAS

[www.pnas.org](http://www.pnas.org)

Supplementary Information for

Observation of others' actions during limb immobilization prevents the subsequent decay of motor performance

Doriana De Marco<sup>a,§,\*</sup>, Emilia Scalona<sup>a,§</sup>, Maria Chiara Bazzini<sup>a,b</sup>, Arturo Nuara<sup>a</sup>, Elisa Taglione<sup>c</sup>, Nicola Francesco Lopomo<sup>a,d</sup>, Giacomo Rizzolatti<sup>a,b,\*</sup>, Maddalena Fabbri-Destro<sup>a,°</sup>, Pietro Avanzini<sup>a,e,°</sup>

- a) Consiglio Nazionale delle Ricerche, Istituto di Neuroscienze, Parma, Italy
- b) Università degli Studi di Parma, Dipartimento di Medicina e Chirurgia, Italy
- c) INAIL, Centro di Riabilitazione Motoria di Volterra, Italy
- d) Università degli Studi di Brescia, Dipartimento di Ingegneria dell'Informazione, Italy
- e) Istituto Clinico Humanitas, Milano, Italy

§These authors contributed equally to the study.

° These authors contributed equally to the study.

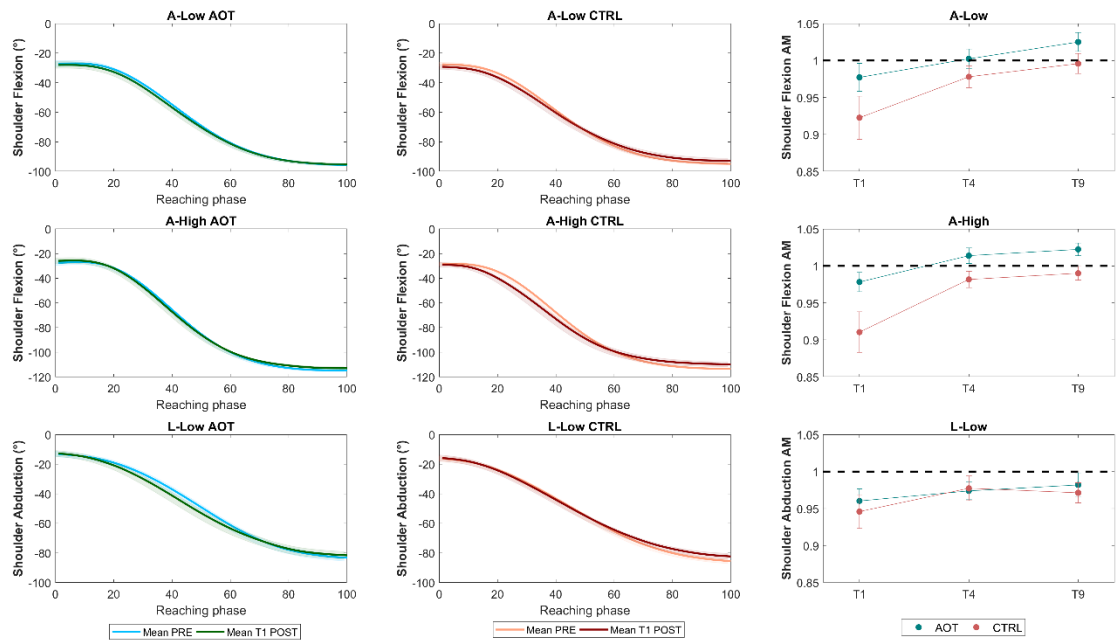
Corresponding authors: Giacomo Rizzolatti and Doriana De Marco

Email: [giacomo.rizzolatti@unipr.it](mailto:giacomo.rizzolatti@unipr.it); [doriana.demarco@in.cnr.it](mailto:doriana.demarco@in.cnr.it);

**This PDF file includes:**

Figures S1

Tables S1 to S3



**Fig. S1.** Left and center columns: time courses of shoulder angles averaged across preimmobilization trials (light colors) for the AOT and CTRL groups (green and red, respectively) for the three movements (A-Low, A-High, and L-Low); time courses of mean shoulder angles acquired during the first trial of the postimmobilization phase (T1) are superimposed in corresponding dark color tones. Right column: means and standard errors of amplitude modulation (AM) evaluated at T1, T4, and T9 for the AOT and CTRL groups (green and red, respectively) and the three movements (A-Low, A-High, and L-Low).

Mov	Index	AOT baseline	CTRL baseline	<i>p</i> -value
A-Low	RD (s)	0.96 (0.11)	1.03 (0.14)	0.18
	VP (m/s)	1.32 (0.21)	1.30 (0.21)	0.71
	MFr (%)	34.12 (20.31)	38.91 (13.36)	0.42
A-High	RD (s)	1.04 (0.13)	1.05 (0.14)	0.79
	VP (m/s)	1.60 (0.25)	1.57 (0.25)	0.78
	MFr (%)	37.39 (14.77)	40.72 (12.00)	0.44
L-Low	RD (s)	1.19 (0.26)	1.22 (0.20)	0.70
	VP (m/s)	1.36 (0.23)	1.37 (0.23)	0.96
	MFr (%)	28.63 (24.89)	27.30 (23.66)	0.86

**Table S1.** Means and standard deviations of the preimmobilization scores (baseline) of reaching duration (RD), velocity peak (VP), and movement fractionation (MFr) for both groups (AOT and CTRL) and each movement (A-Low, A-High, and L-Low). The *p*-values are relative to unpaired *t*-tests between groups.

		ANOVA				Bayesian Analysis	
Movement	Index	F	p	$\eta^2$	post-hoc	BF <sub>10</sub>	BF Robustness
Main Effect Time	RD (s)	18.83	<0.001	0.33	T1 > T4 T1 > T9	> 100	Extreme
	VP (m/s)	28.27	<0.001	0.42	T1 < T4 T1 < T9	> 100	Extreme
	MFr (%)	10.41	<0.001	0.21	T1 > T4 T1 > T9	> 100	Extreme
	AM <sub>Elb</sub>	10.06	<0.001	0.21	T1 < T4 T1 < T9	> 100	Extreme
	AM <sub>Sho</sub>	9.05	<0.001	0.19	T1 < T4 T1 < T9	> 100	Extreme
Main Effect Movement	RD (s)	1.78	0.175	0.04		0.12	No Evidence
	VP (m/s)	2.36	0.101	0.06		0.32	No Evidence
	MFr (%)	9.90	<0.001	0.21	L-Low>A-Low L-Low>A-High	> 100	Extreme
	AM <sub>Elb</sub>	8.69	<0.001	0.22	L-Low<A-Low L-Low<A-High	48.91	Very Strong
	AM <sub>Sho</sub>	1.22	0.299	0.03		0.11	No Evidence
Main Effect Group	RD (s)	0.41	0.524	0.01		0.27	No Evidence
	VP (m/s)	0.36	0.554	0.01		0.19	No Evidence
	MFr (%)	7.55	0.009	0.16		5.15	Moderate
	AM <sub>Elb</sub>	10.98	0.002	0.22		15.94	Strong
	AM <sub>Sho</sub>	3.76	0.06	0.09		1.01	No Evidence

**Table S2.** ANOVA and Bayesian results for the main variables: reaching duration (RD), velocity peak (VP), movement fractionation (MFr), amplitude modulation of the elbow (AM<sub>Elb</sub>), and amplitude modulation of the shoulder (AM<sub>Sho</sub>).

		ANOVA				Bayesian Analysis	
Movement	Index	F	p	$\eta^2$	post-hoc	BF <sub>01</sub>	BF Robustness
Main Effect Time	R <sup>2</sup> <sub>Elb</sub>	2.79	0.067	0.07		0.84	No Evidence
	AOff <sub>Elb</sub>	0.06	0.943	0.00		30.25	Very Strong
	R <sup>2</sup> <sub>Sho</sub>	7.30	0.001	0.16	T1 < T4 T1 < T9	0.04	No Evidence
	AOff <sub>Sho</sub>	0.50	0.605	0.01		12.72	Strong
	Trunk (mm)	0.14	0.866	0.04		29.39	Strong
Main Effect Movement	R <sup>2</sup> <sub>Elb</sub>	10.36	<0.001	0.21	L-Low<A-Low L-Low<A-High	< 0.01	No Evidence
	AOff <sub>Elb</sub>	5.25	0.007	0.12	L-Low<A-Low L-Low<A-High	0.08	No Evidence
	R <sup>2</sup> <sub>Sho</sub>	2.54	0.085	0.06		5.77	Moderate
	AOff <sub>Sho</sub>	0.33	0.717	0.01		22.93	Strong
	Trunk (mm)	2.70	0.073	0.06		0.25	No Evidence
Main Effect Group	R <sup>2</sup> <sub>Elb</sub>	0.32	0.573	0.01		3.85	Moderate
	AOff <sub>Elb</sub>	0.55	0.461	0.01		2.49	Anecdotal
	R <sup>2</sup> <sub>Sho</sub>	1.01	0.321	0.03		4.05	Moderate
	AOff <sub>Sho</sub>	1.49	0.229	0.03		2.62	Anecdotal
	Trunk (mm)	1.66	0.205	0.04		0.51	No Evidence

**Table S3.** ANOVA and Bayesian results for the control variables: R<sup>2</sup> of the elbow (R<sup>2</sup><sub>Elb</sub>), offset of the elbow (AOff<sub>Elb</sub>), R<sup>2</sup> of the shoulder (R<sup>2</sup><sub>Sho</sub>), offset of the shoulder (AOff<sub>Sho</sub>), and trunk compensation movement (Trunk).