Supplementary Materials

Supplementary Tables

From -3 to +3, please answer to the following statements:

Q1	**During the virtual reality experience, I had the sensation of finding myself** (from -3, in the laboratory, to + 3, in the virtual reality environment).	**-3 -2 -1 0 +1 +2 +3**
Q2	**During the virtual reality experience, I felt as if the virtual environment were real** (from -3, completely disagree, to + 3, completely agree).	**-3 -2 -1 0 +1 +2 +3**
Q3	**During the virtual reality experience, I felt as if I were truly inside the virtual environment** (from -3, completely disagree, to + 3, completely agree).	**-3 -2 -1 0 +1 +2 +3**
Q4	**There were moments when the virtual environment seemed more real to me than the room I was actually in** (from -3, completely disagree, to + 3, completely agree).	**-3 -2 -1 0 +1 +2 +3**
Q5	**To what extent did you feel like you were "really there", inside the virtual environment** (from -3, very weakly, to + 3, very strongly).	**-3 -2 -1 0 +1 +2 +3**
Q6	**The virtual environment seemed..** (from -3, a place where I had already been, to + 3, a place where I had never been).	**-3 -2 -1 0 +1 +2 +3**
Q7	**When I think about the virtual environment...** (from -3, it feels like I've watched a movie, to + 3, it seems like a place where I've been).	**-3 -2 -1 0 +1 +2 +3**

Supplementary Table 1. Virtual reality experience questionnaire (Slater et al., 2000)

Indicate how much each symptom below is affecting you right now.

Q1(Nausea)	**General discomfort**	None Slight Moderate Severe
Q2 (Oculo-motor)	**Fatigue**	None Slight Moderate Severe
Q3 (Oculo-motor)	**Headache**	None Slight Moderate Severe
Q4 (Oculo-motor)	**Eye strain**	None Slight Moderate Severe
Q5 (Oculo-motor)	**Difficulty focusing**	None Slight Moderate Severe
Q6 (Nausea)	**Salivation increasing**	None Slight Moderate Severe
Q7 (Nausea)	**Sweating**	None Slight Moderate Severe
Q8 (Nausea)	**Nausea**	None Slight Moderate Severe
Q9 (Oculo-motor)	**Difficulty concentrating**	None Slight Moderate Severe
Q10 (Oculo-motor)	**« Fullness of the Head »**	None Slight Moderate Severe
Q11 (Oculo-motor)	**Blurred vision**	None Slight Moderate Severe
Q12 (Nausea)	**Dizziness with eyes open**	None Slight Moderate Severe
Q13 (Nausea)	**Dizziness with eyes closed**	None Slight Moderate Severe
Q14 (Nausea)	**Vertigo** (experienced as loss of orientation with respect to vertical upright)	None Slight Moderate Severe

Q15 (Nausea)	**Stomach awareness** (indicate a feeling of discomfort which is just short of nausea)	None Slight Moderate Severe
Q16 (Nausea)	Burping	None Slight Moderate Severe

Supplementary Table 2. Simulator Sickness Questionnaire (Kennedy et al., 1993). Items and relative factor of the questionnaire (Bouchard et al., 2007; 2009;2021): factor Nausea (items 1, 6, 7, 8, 12, 13, 14, 15, 16) and factor Oculo-motor (items 2, 3, 4, 5, 9, 10, 11)

Supplementary Results

Virtual Reality Experience Questionnaire results

The assessment of the sense of presence (i.e., the belief of being in a other world than where their body are located) during the VR experience was conducted using the Virtual Reality Experience scale (Slater et al., 1994, 2000; Supplementary Table 2). The 7-point questionnaire investigated the VR experience through 7 items, assessing three dimensions: (i) the sense of "*being there*", measuring the psychological state within the VR environment (Item 1, 3, and 5), (ii) the degree to which the experience in the virtual environment feels more "*real or present*" compared to daily reality (Item 2, and 4), and (ii) the *locality*, the feeling of visiting somewhere rather that just seeing something (Item 6 and 7). First, we computed a composite index of the sense of presence by aggregating scores from all dimensions (Item 6 was reversed). Overall, participants seem to perceive themselves as being immersed in a real environment, as if they were visiting it (M=0.43; SE=0.20; 95% CI[0.01, 0.85]). Specifically considering the three dimensions, we observed a positive score for each dimension (sense of being there: M = 0.58; SE = 0.23; CI [0.11, 1.05]; feels of reality of the virtual environment: M = 0.17, SE = 0.30; CI [-0.43, 0.77]; Locality: M=0.47; SE = 0.27; CI [-0.07, 1.01]). Therefore, the VR environment in our study induced participants to feel immersed and experience a sense of presence within the experienced environment.

Simulator Sickness Questionnaire (SSQ) results

The assessment of side effects during the VR experience was conducted at the conclusion of the experiment session using the Simulator Sickness Questionnaire (SSQ, Kennedy et al., 1993; Supplementary Table 3). This questionnaire comprises 16 items designed to evaluate various symptoms, utilizing a four-point scale (0 = None, 3 = Severe).

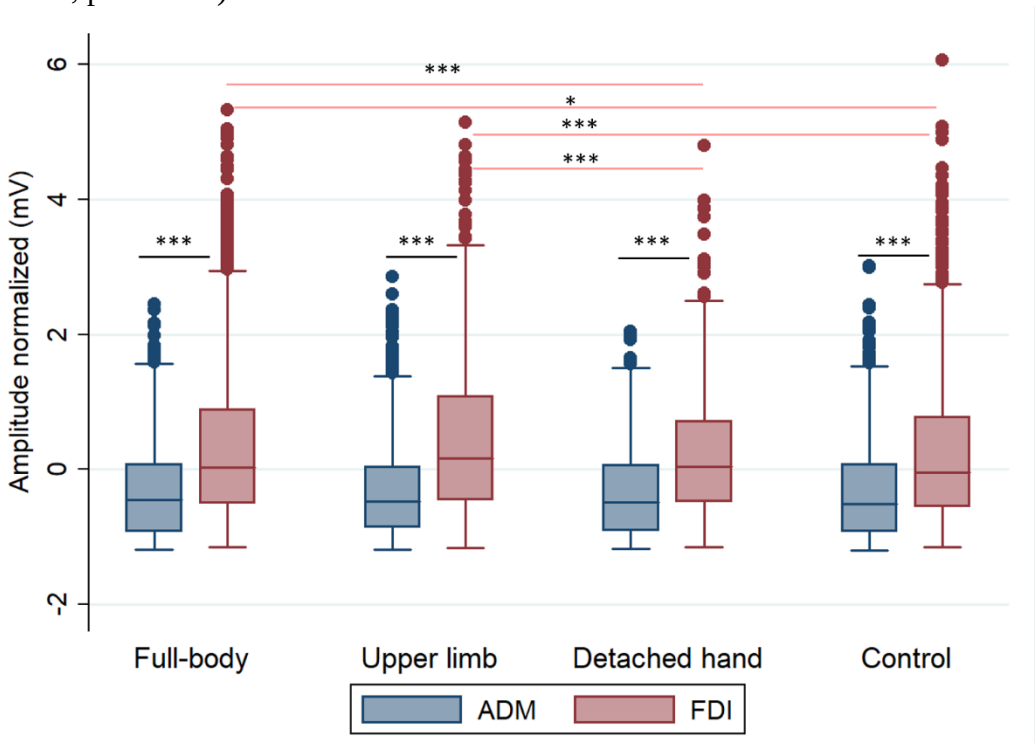
In adherence to the methodology previously proposed by Bouchard et al. (2007, 2009, 2021) and Brown et al. (2022), raw scores for each item were considered. Specifically, the scores of each item were summed to compute the total score, with a possible range of 0-48.

By applying a subjective threshold that considered participants reporting only slight symptoms (score = 1) for each item, it was observed that all participants recorded a raw score below 16 (M = 4.47; SE = 0.599; Maximum = 11, Minimum = 0; 95% CI [3.25, 5.69]). Our results indicate that side effects were rated, on average, below the "slight" level for all items. Importantly, no participants found it necessary to interrupt the immersive experience due to the sensation of sickness. More specifically, we also considered the scores related to the two main factors of the questionnaire (i.e., Nausea and Oculumotor factors) as outlined in the revised version of the questionnaire interpretation by Bouchard et al. (2007, 2009, 2021). A higher score was observed for the Oculomotor factor (M = 3.56, SE= 0.477, 95% CI [2.59, 4.54]) in comparison to the Nausea Factor (M = 0.906, SE = 0.231, 95% CI

[0.436, 1.38]. This finding implies that the side effects attributed to our VR environment were more related with oculomotor symptoms, such as eye strain, difficulty concentrating and focusing, blurred vision, and the sensation of "Fullness of the Head," fatigue, and headache.

Analysis on MEPs considering the control condition

MEPs were also recorded during a control condition, in which only a fixation cross was presented, both at the beginning and at the end of the experimental session (20 trials each). We computed the mean between control MEPs recorded at the beginning and at the end of each session. A Linear Mixed Model (mixed function in stats) was conducted on MEPs recorded during the observation of the static hand in the three experimental condition (Full-Body, Upper Limb, Detached Limb) and during the observation of the fixation cross (i.e., control condition). We considered as fixed factors: Muscle (FDI, ADM), Condition (Full-Body, Upper Limb, Detached Limb, Control), and their interaction. To properly address inter-subject variability, we included participants intercept as a random effect variable. The results showed a main effect on Muscle showing higher muscle activation on FDI compared to ADM across all the conditions: Full Body ($z=18.33$, $p< 0.0001$), Upper Limb ($z=19.59$, $p< 0.0001$), detached hand ($z=17.70$, $p< 0.0001$), and Control ($z=17.57$, $p< 0.0001$) conditions. The results showed an interaction between Muscle and Condition in the specifically in the Detached ($z=-2.44$, $p=0.01$) and Control (fixation cross) ($z=-1.92$, $p=0.05$) conditions. The results confirmed that the mere observation of a static hand from a first-person perspective, in the Full-Body and Upper Limb conditions, is effective in enhancing M1 activation in the FDI muscle. Indeed, this activation was notably stronger compared to scenarios where the hand is presented completely detached to the limb, as well as when compared to observing a fixation cross (i.e., control condition). Additionally, the results also confirmed the muscle specificity of action observation in M1 activation: the differences observed between conditions are evident only in the FDI muscle. In specific, post-hoc comparisons (Sheffe test) show a significant enhanced activation of Full Body and Upper Limb conditions compared to Detached hand ($z= -4.07$, $p< 0.01$; $z=-3.12$, $p=0.02$) and Control ($z=-5.41$, $p< 0.0001$; $z=-4.55$, $p< 0.0001$) conditions.



Supplementary Figure 1. Results of the 2 (Muscle) *4 (Condition) Multilevel mixed-models on MEPs Amplitude (mV) recorded during the observation of the static hand in the three experimental condition (Full-Body, Upper Limb, Detached Limb) and in the control one. We set participants intercept as a random effect

variable. In the boxplots, the medians are shown as horizontal lines, and the boxes are the interquartile ranges (IQR). The whiskers are between max (min score, lower quartile -1.5 IQR) to min (max score, upper quartile + 1.5 IQR). If there are values outside the whiskers, these are conventionally called “outliers” and are shown by (∘). * $p<0.05$, ** $p<0.01$, *** $p<0.0001$.

	Mean	**SE**	**Min**	**Max**
Full-body ADM	-0.31	0.02	-1.19	2.45
Upper limb ADM	-0.32	0.02	-1.19	2.85
Detached hand ADM	-0.36	0.02	-1.18	2.04
Control ADM	-0.35	0.02	-1.20	3.02
Full-body FDI	0.36	0.04	-1.16	5.32
Upper limb FDI	0.44	0.04	-1.16	5.14
Detached hand FDI	0.22	0.03	-1.16	4.79
Control FDI	0.25	0.03	-1.15	6.06

Supplementary Table 3. MEPs Amplitude Median (mV), Standard Error (SE), and minim and maximum values across Conditions and Muscle.