Supplementary File 1: Detailed Experimental Procedures

This file describes in detail the experimental procedures that are mentioned in the manuscript titled "**Post Hoc Event-Related Potential Analysis of Kinesthetic Motor Imagery-Based Brain–Computer Interface Control of Anthropomorphic Robotic Arms**", submitted in the MDPI Electronics journal. The data were collected and published through the concluded CSI:Brainwave project (https://medphys.med.auth.gr/project/csi-brainwave) (NCT02443558) [19], and the procedures presented below have been published in peer-reviewed published manuscripts, available through a Creative Commons 4.0 licence [21,22].

Recruitment

The institutional bioethics committee approved the experimental protocol, and all subjects provided a signed informed consent form prior to their participation. Ten subjects with SCI (eight male, two female) and ten healthy age- and gender-matched individuals were recruited in total. The SCI group had a mean age of 46.0 years (range 28–74 , standard deviation (std) 17.64), while the healthy group had a mean age of 46.20 years (range 27–74, std 18.27). The subjects had no prior experience in BCI or robotics. In the SCI group, 9 out of 10 patients had incomplete injury. Four patients were classified as AIS D (40%), two were AIS B (20%), two were AIS E (20%), one had complete injury and was classified as AIS A (10%), and one patient was classified as AIS C (10%). Regarding level, 70% exhibited cervical injuries, whereas the remaining 30% displayed thoracic injuries. Moreover, the predominant cause of injury, in 60% (6/10) of patients, was motor vehicle accidents (MVA), while in 30% of participants, the injury was induced by fall from heights (Fall), and one patient reported other causes.

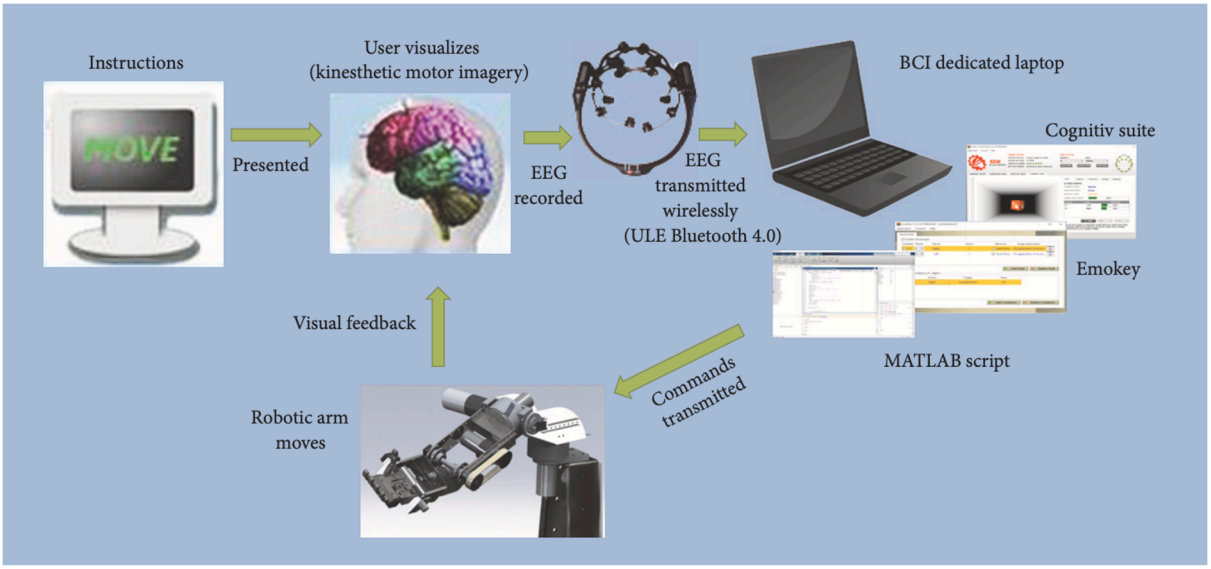


Figure S1: Brain–robot interface loop, using a wireless commercial EEG device for unobtrusiveness and simplicity of the system [21,22].

BCI Experiment

The subjects were first asked to mentally rehearse 32 different movements of the upper extremities, while watching a set of arms randomly performing those movements on a computer screen. This experience was aimed at preparing participants for the BCI tasks they would later be required to perform. The arms, torso, and legs of the subjects were covered with a black curtain during the whole experiment to facilitate registration into their body schema. Following, the subjects sat across from a computer monitor, between two Mercury 2.0 robotic arms, located in the Thessaloniki Active and Healthy Aging Living Lab technology showcase room (Thess-AHALL, member of ENoLL). Subjects wore an Emotiv EPOC headset, and they began training with the BCI modality using kinesthetic motor imagery (KMI) of

movements of the left and the right arms. Action power threshold was set at 50%, and all subjects were above threshold during training. Three imagery classes were trained (resting state, left, and right). Five training cycles were allowed for left and right, using continuous mental rehearsal of all movements of the left and right arm, respectively (as in the videos the subjects watched). Training skills (Train-L, Train-R) classes were recorded. Following BCI training, the subjects were provided with written commands on the monitor to move a specific DoF towards a specific direction (**Figure S1**). A total of 32 different commands were given in total, and the subjects were asked to use the trained KMI skill in order to control the robotic arms to perform those actions. Each command was projected for 30 sec, with a 5 sec rest between them (**Figure S2**). During the 30 sec period, the subject attempted to perform the movement as many times as possible by giving the desired direction of the imagery class (left or right). The BCI detected as correct (desired) any activation of the class corresponding to the arm currently targeted and provided the output to move the arm as per the instruction (positive feedback). Incorrect (undesired) activation that was detected resulted in an opposite motion of the target robotic arm (negative feedback). Desired and undesired commands that were detected by the BCI program were recorded through the MATLAB script.

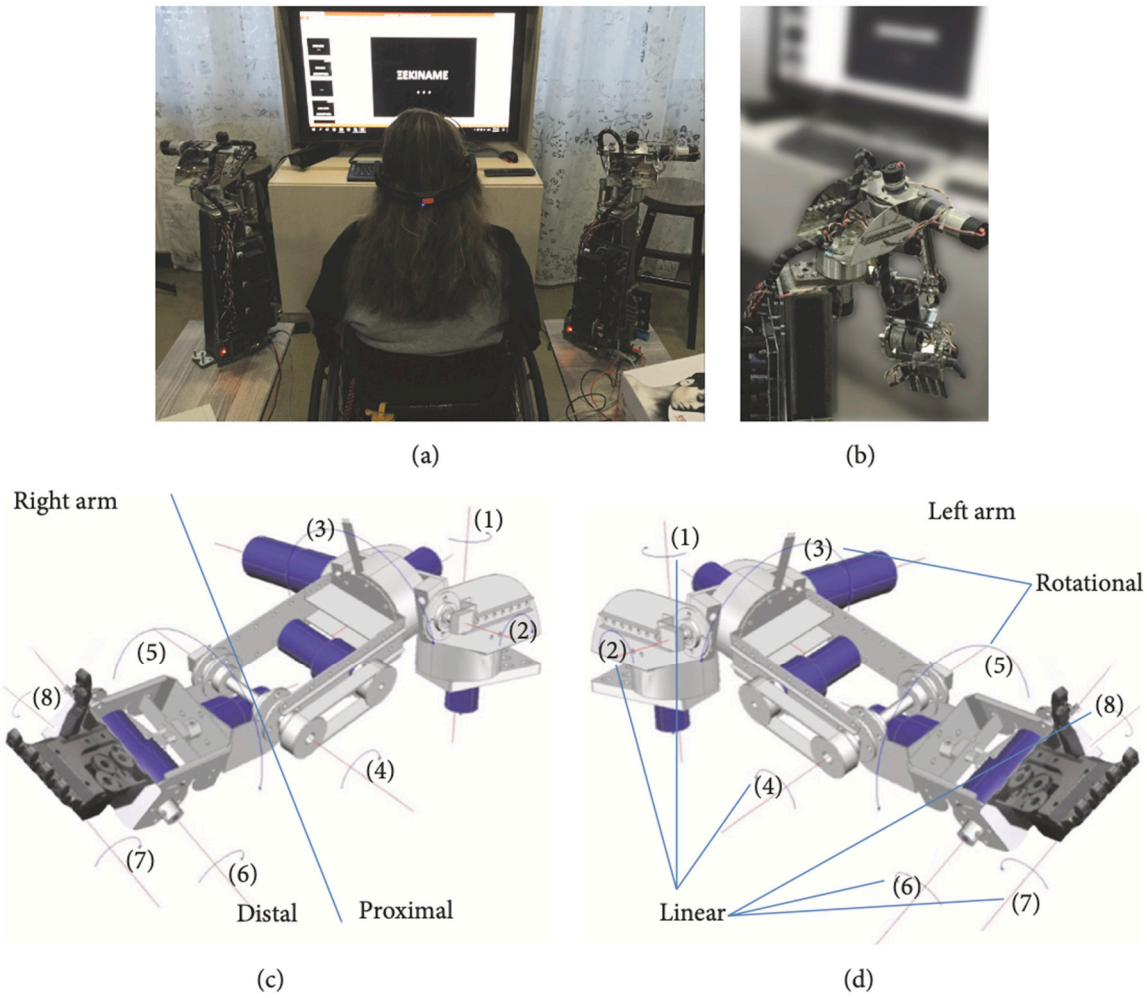


Figure S2: The experimental setup in Thess-AHAL. (a) SCI subject seated across from the TV/computer monitor and between two robotic arms, wearing a wireless commercial EEG device; (b) close-up of a "Mercury 2.0" house-built robotic arm; (c) the right robotic arm, showing eight possible DoFs, grouped into proximal and distal movements; (d) the left robotic arm, showing DoFs that result in rotational or linear movement. Each DoF allows movement towards two possible directions [21,22].