

Study of movement coordination and muscular force application in a reach and grasp drawer task in non-human primate

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INTRODUCTION

- Manual dexterity is a complex motor behavior common to non-human primates and human beings. It is mainly controlled by superior motor centers of the central nervous system (CNS), particularly by the primary motor cortex (M1).
- The quantification of manual dexterity allows to detect and assess precisely functional recovery after brain injury affecting M1.
- We are interested in the precision grip movement which is the opposition between the index and the thumb.
- The aim of the present work is to quantify the motor performance in a reach and grasp drawer task before and after a lesion of the hand area in the primary motor cortex in *Macaca fascicularis*.

METHODS

- We trained eight adult macaque monkeys (2 males and 6 female) to perform the reach and grasp drawer task in which animals had to pull a drawer against adjustable levels of resistance and to grasp a food pellet inside the drawer, using one or the other hand.
- The set of data obtained were analyzed: 1) the grip force to grasp and hold the knob; 2) the load force exerted by the arm to pull and open the drawer.
- Different levels of resistance were applied against the pulling of the drawer.
- The drawer is connected to a computer which records three different parameters in time: first the displacement of the drawer, second the force needed to grasp the knob of the drawer and, finally, the force needed to open the drawer (load force) during the task.
- The analysis included 8 different cursors, corresponding to the major discrete events during the task.
- Preliminary data were derived from 5 sessions in one animal tested for both hands. Statistical analysis was performed using a student t-test.
- Slope force measure is the value of the slope between the onset of the force and the maximal value of the corresponding force.

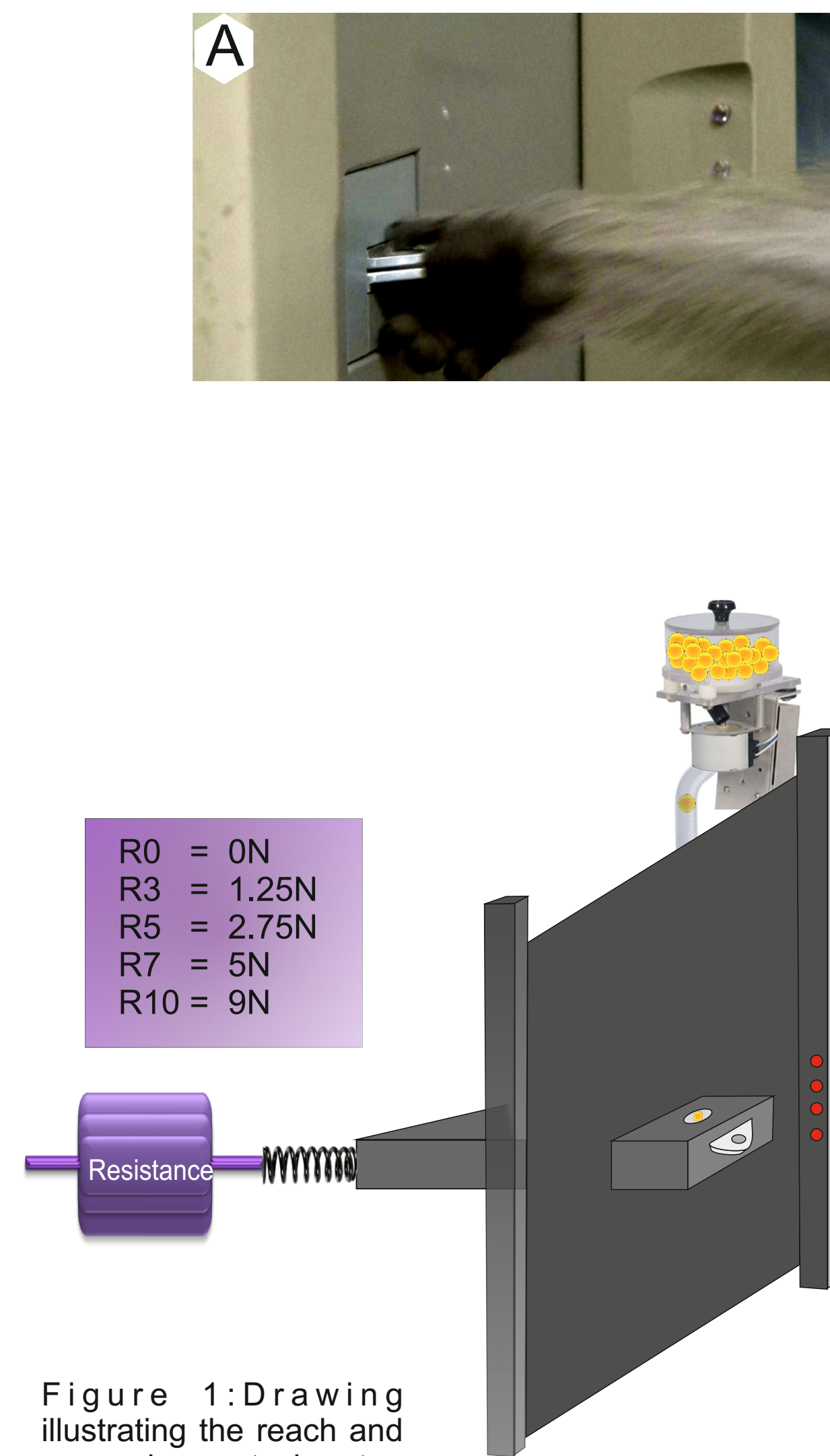


Figure 1: Drawing illustrating the reach and grasp drawer task setup with adjustable resistance (N).

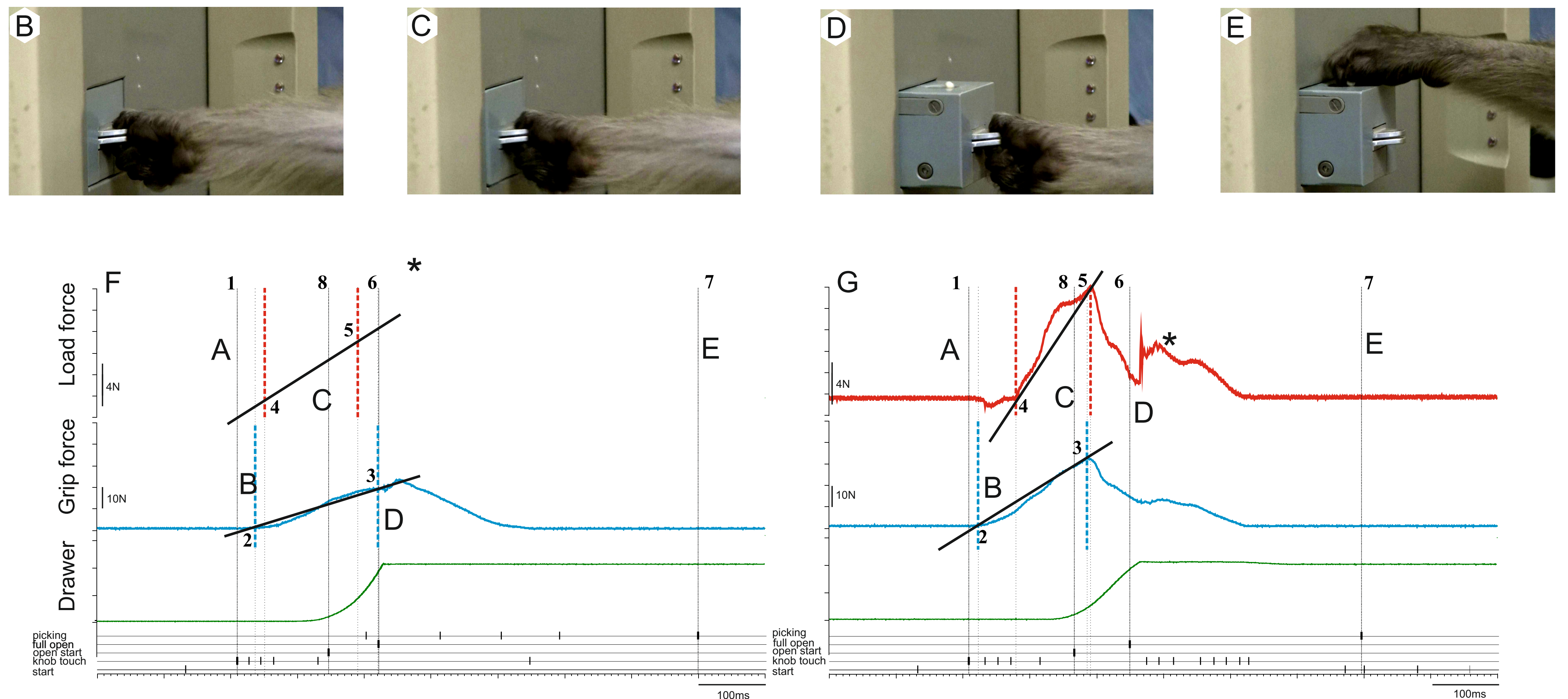


Figure 2: Unfolding of a trial during a session of the reach and grasp drawer task performed by a monkey with the right hand. A-E: Five photographs showing key moments during the task. They correspond to: A knob touch, B onset grip force, C open start of the drawer, D full open of the drawer and E picking of the pellet. F and G show the computer recording of a trial at resistance 0 (panel F) and at resistance 5 (panel G). Both graphs show three online recordings during one trial: the load force (red), the grip force (blue), and the drawer displacement (green). Discrete events are: #1 is the knob touch (A), #2 is the onset of grip force (B), #3 is the maximal grip force, #4 is the onset of load force, #5 is the maximal load force, #6 is the full open (D), #7 is the picking (E) and finally #8 is the start open (C). Cursors #1, 6, 7 and 8 are placed on markers given by the sensors placed on the drawer setup; the other cursors are manually located. Artefacts (*) due to the blocking of the drawer in full open position was not taken into account. Time scale bar 100 ms.

RESULTS

- Our results have shown that maximal grip force and maximal load force increase as a function of the increase of the resistance against the pulling of the drawer. The slope grip force remained constant as the resistance increased whereas the slope load force did not; in fact it is constant for resistances 0 and 3 but it increases at resistance 5.
- No statistical difference was observed between the right and the left hands.

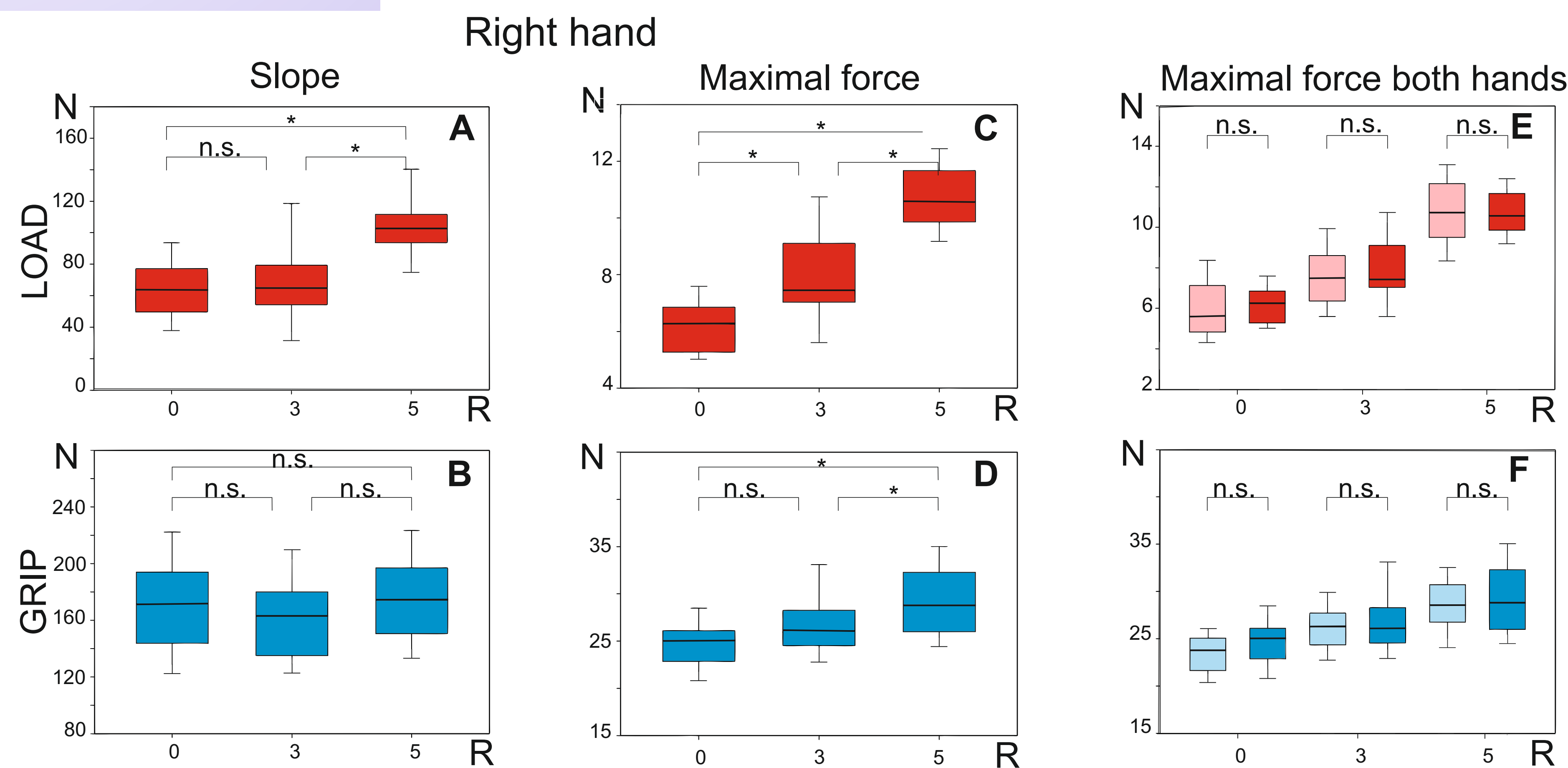


Figure 3: Box plots showing quantitative analyses of the recorded forces (load force in red and grip force in blue) obtained with the right hand on one animal at resistance 0, 3 and 5 N (A-D). A represent the slope of the load force, B is the slope of the grip force, C is the maximal load force and D is the maximal load force. Box plots E and F show respectively the comparison with the left hand for the maximal grip force (light blue) and for the maximal load force (pink). The forces are expressed in Newtons (N).

CONCLUSIONS

- The reach and grasp drawer task is a good behavioral model to study the movements coordination and the application of forces for the execution of fine hand movement (precision grip).
- The load force is more sensitive to the increase of the resistance than the grip force.
- We expect dramatic changes after cortical lesion affecting the primary motor cortex hand area.