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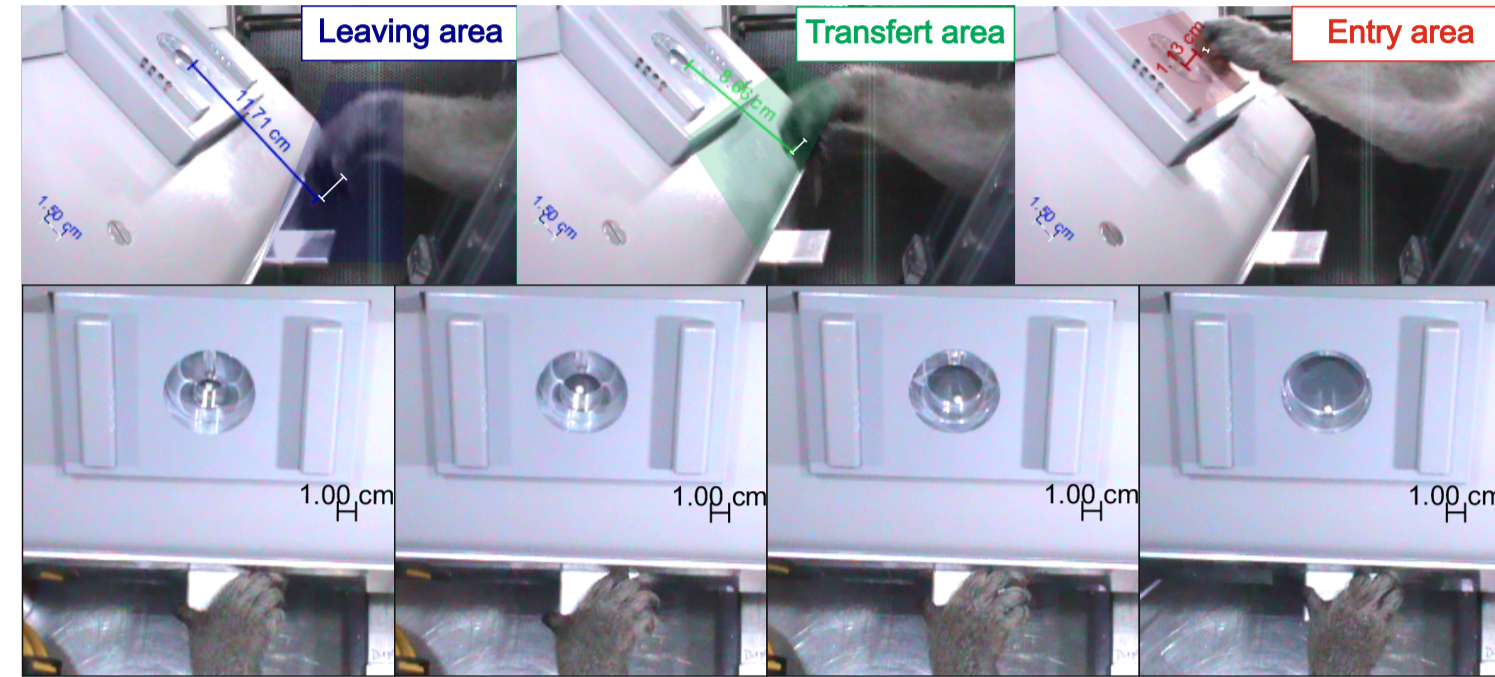
Introduction: Behavior and its different parameters are differently affected by motor cortical injury, depending on its size and its location. Precision grip, an example of sophisticated motor control and a specialty of primates, is therefore a pertinent model to elucidate the mechanisms involved in motor recovery from cortical lesion using different motor tasks. This study aimed at quantitatively assessing different motor attributes of grasping and precision grip movements in adult monkeys, based on two manual dexterity tasks: a modified version of the "Brinkman board" task and a modified version of the "Klüver board" task. These complementary approaches compared in the same macaque monkey the effects on different parameters of an unilateral permanent lesion in the left primary motor cortex targeted to the hand area followed secondly by a long-term inactivation of the contralesional intact right primary motor cortex.

Method:

Behavioral tests

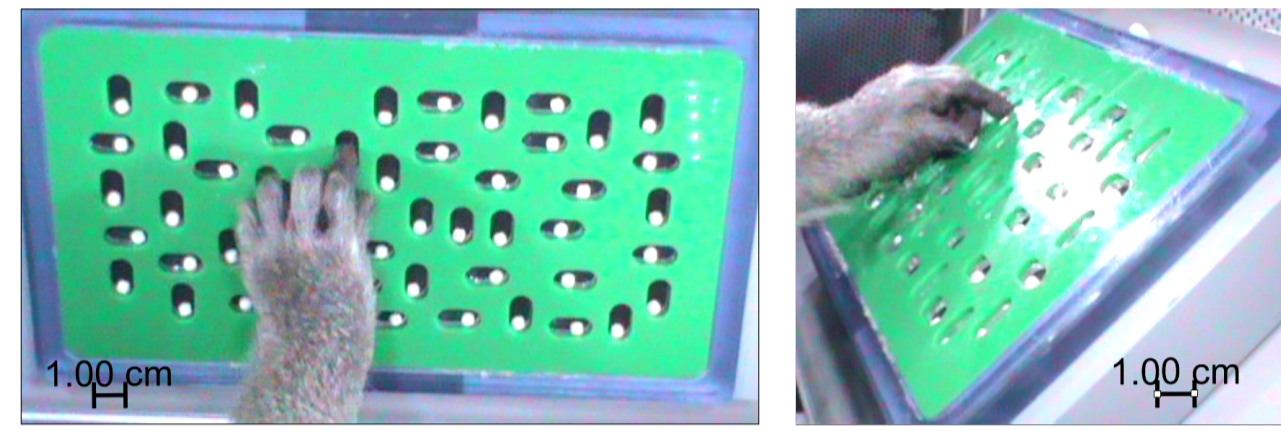
Modified Klüver board:

Pellets retrieved from four slots of different size, allowing pellet retrieval with one finger in the 15 mm diameter slot, two fingers in the 21 mm diameter slot, three fingers in the 30 mm diameter slot and four fingers in the 40 mm diameter slot. Pellets were delivered by constant press on a lever.



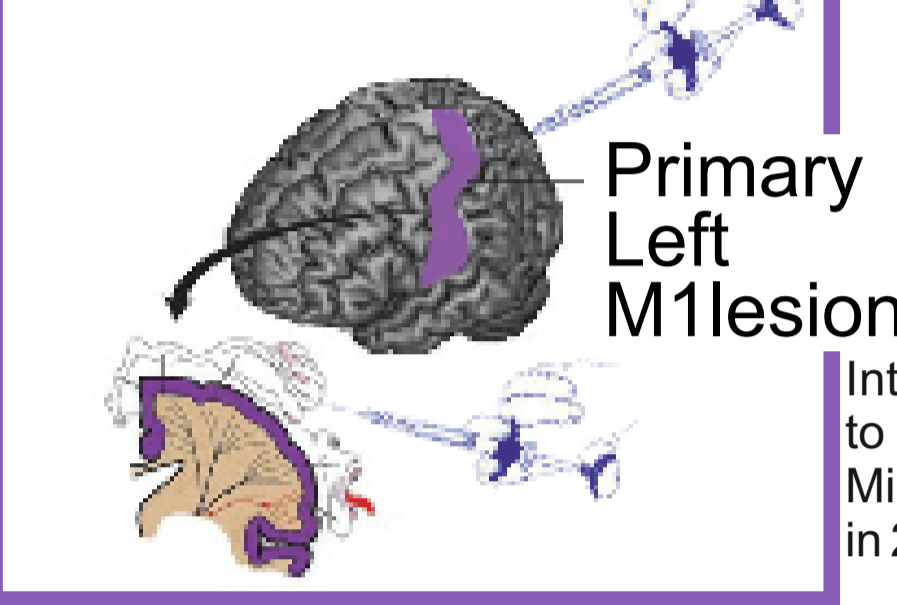
Modified Brinkman board:

Pellets retrieved from 25 horizontal slots and 25 vertical slots randomly distributed on the board.



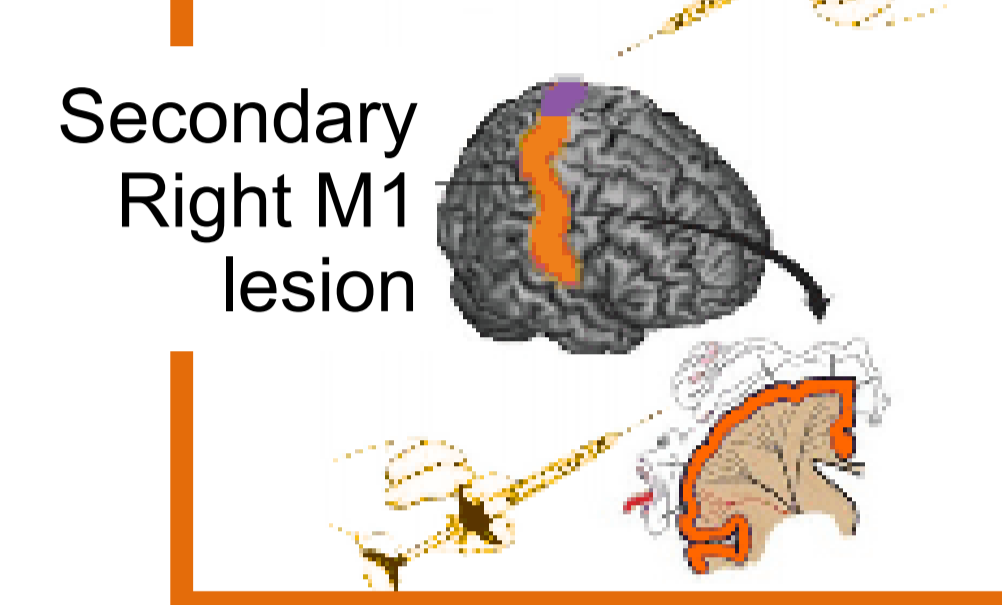
Behavioral tests

Ibotenic acid



Intracortical microstimulation to target hand area of left M1. Microinfusion of Ibotenic acid in 24 fingers sites, 1µl per sites.

Muscimol



Intracortical microstimulation to target hand area of right M1. Microinfusion of muscimol in 6 fingers sites, 1µl per sites.

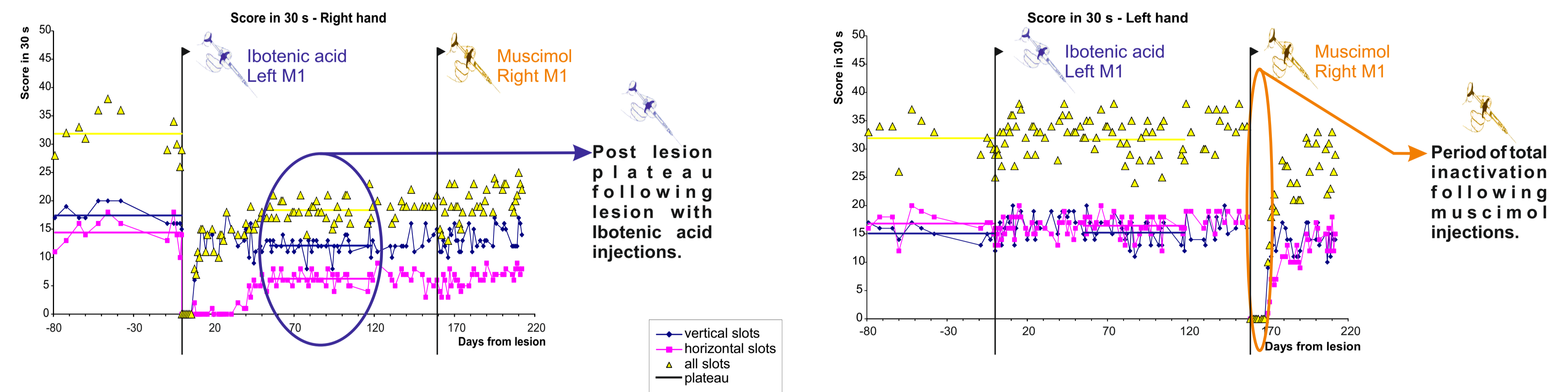
Behavioral parameters

Example of the time course of recovery and effects of M1 lesions in the Modified Brinkman board:

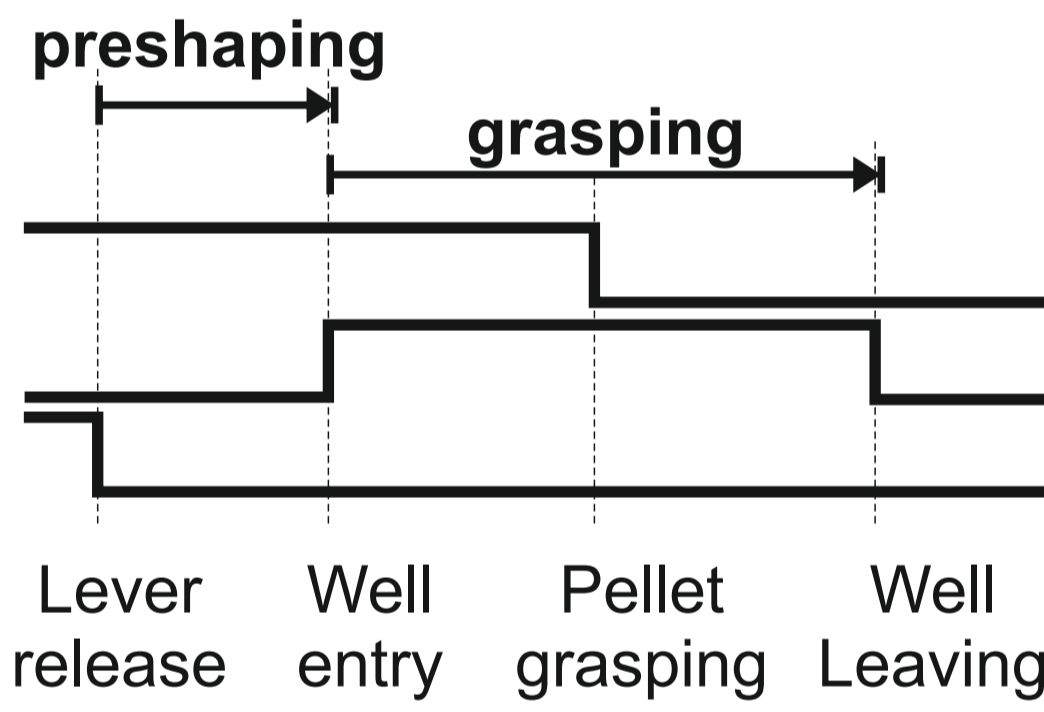
Modified Brinkman board:

Score: number of pellets retrieved from vertical and horizontal slots during the first 30 sec of the task, before and after the lesion.

Contact time: mean of the 5 first horizontal and the 5 first vertical correctly retrieved pellets. It represents the time between entry of finger in the slot and the output of pellet out of the slot. For unsuccessful trials (when less than 5 pellets retrieved), a maximum contact time was fixed at 3 seconds.



Modified Klüver board:



Grasping:

Retrieval time: mean value of the time spent to correctly retrieve pellets from the slot per session. Each session represents 30 to 50 trials for each well.

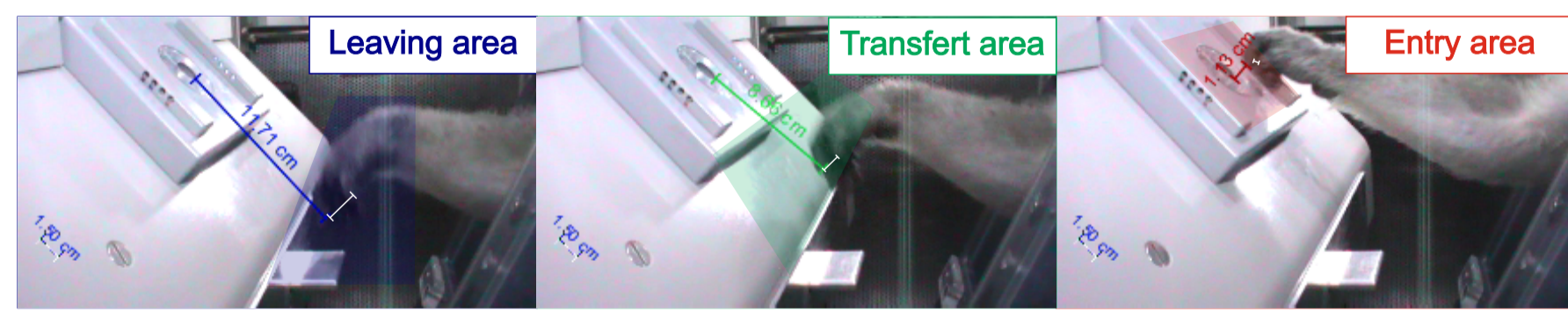
Grasping strategy: two parameters measured for the 20 to 30 first trials:

- the number of trials per number of finger in slot.
- the number of flexion per retrieval per number of finger per slot.

Preshaping:

Reaching time: time between the lever release and finger entrance in the well. Each session represent 30 to 50 trials for each well.

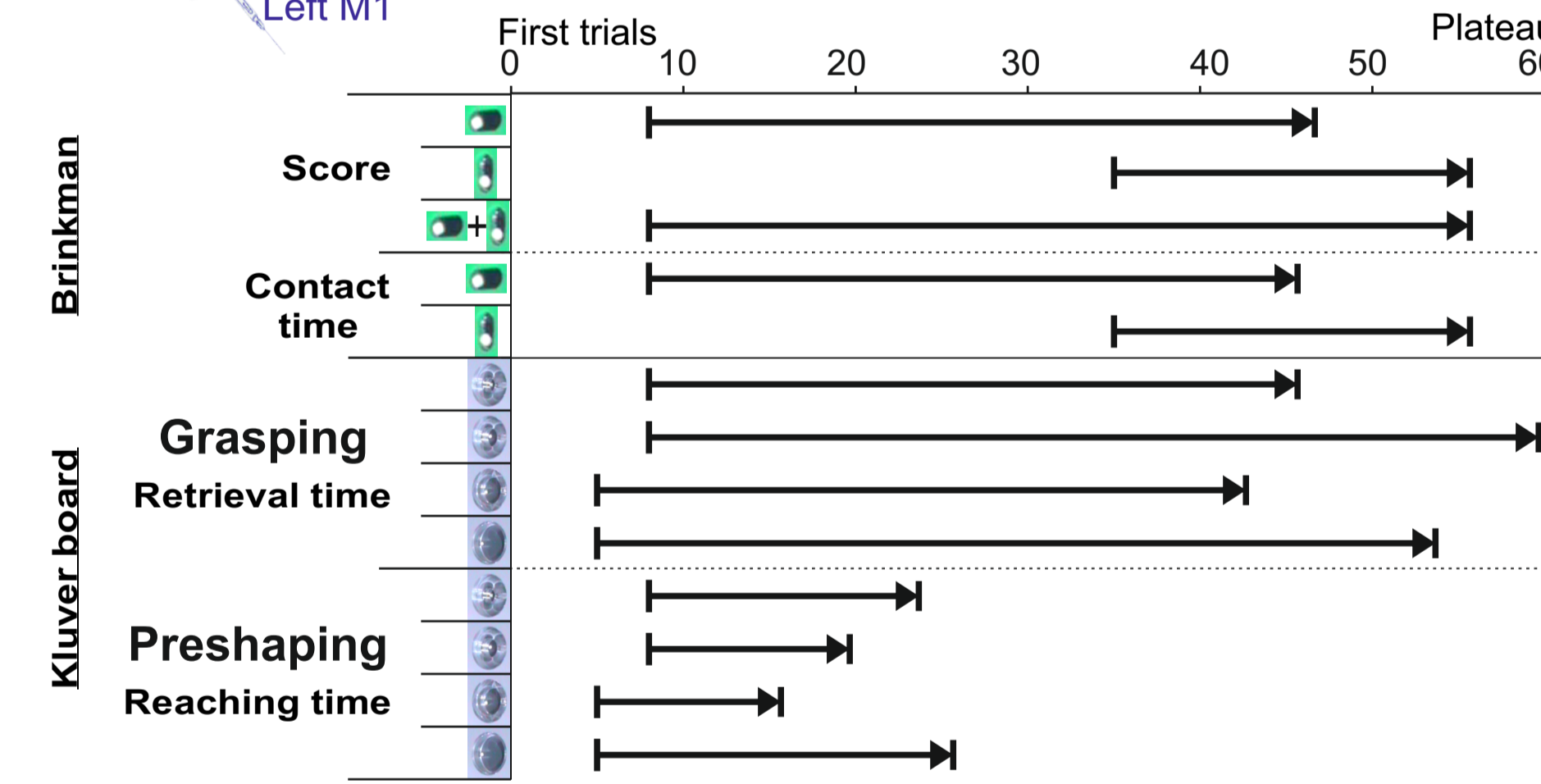
Preshaping strategy: measure of the distance between the tip of the index and the tip of the thumb during the reaching period. Average of the finger distances of the 5 first correctly retrieved pellets distributed in 3 groups corresponding to areas based on the distances from the lever to the bottom border of the well: the leaving area, the transfert area and the entry area.



Results:

Behavioral parameters : score and times

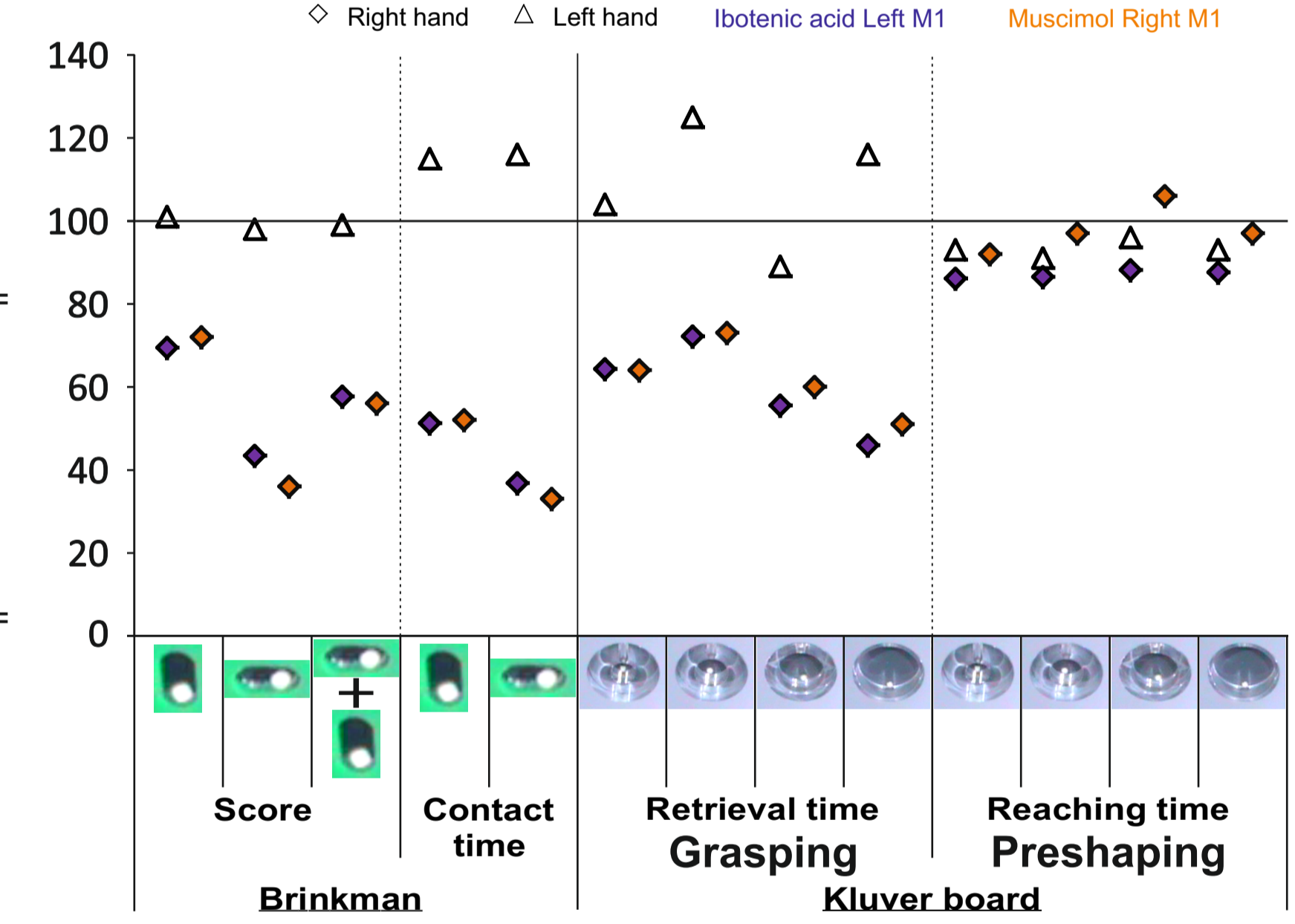
Time for recovery
(in number of days from the first trial to the first day of postlesion plateau)



Percentages of recovery: mean values at pre-lesion and post-lesion plateau:
- for score and retrieval time = PostL/PreLx100;
- for contact time and reaching time = PreL/PostLx100.

Percentages of recovery - effect of muscimol inactivation: mean values at pre-lesion and period of total inactivation following muscimol injections:
- for score and retrieval time = PostL/PreLx100;
- for contact time and reaching time = PreL/PostLx100.

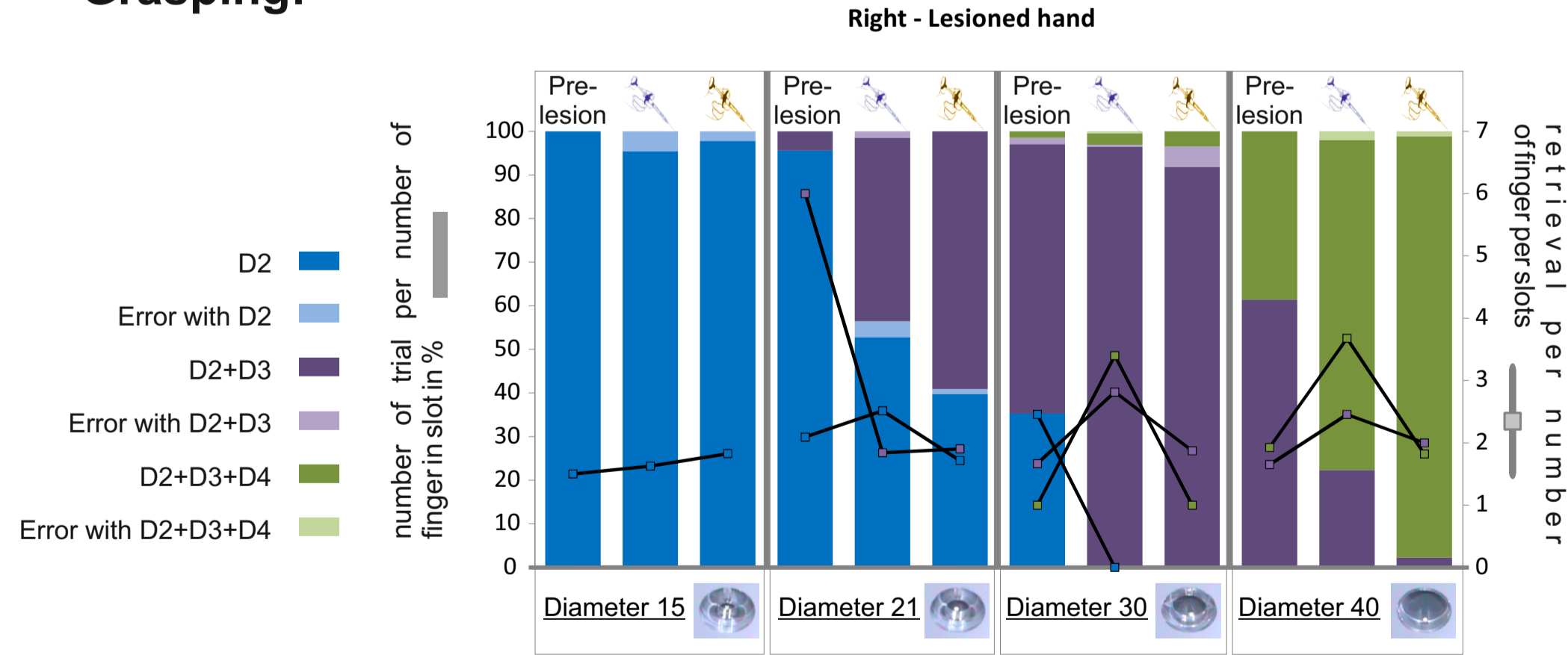
Percentage of recovery (%)



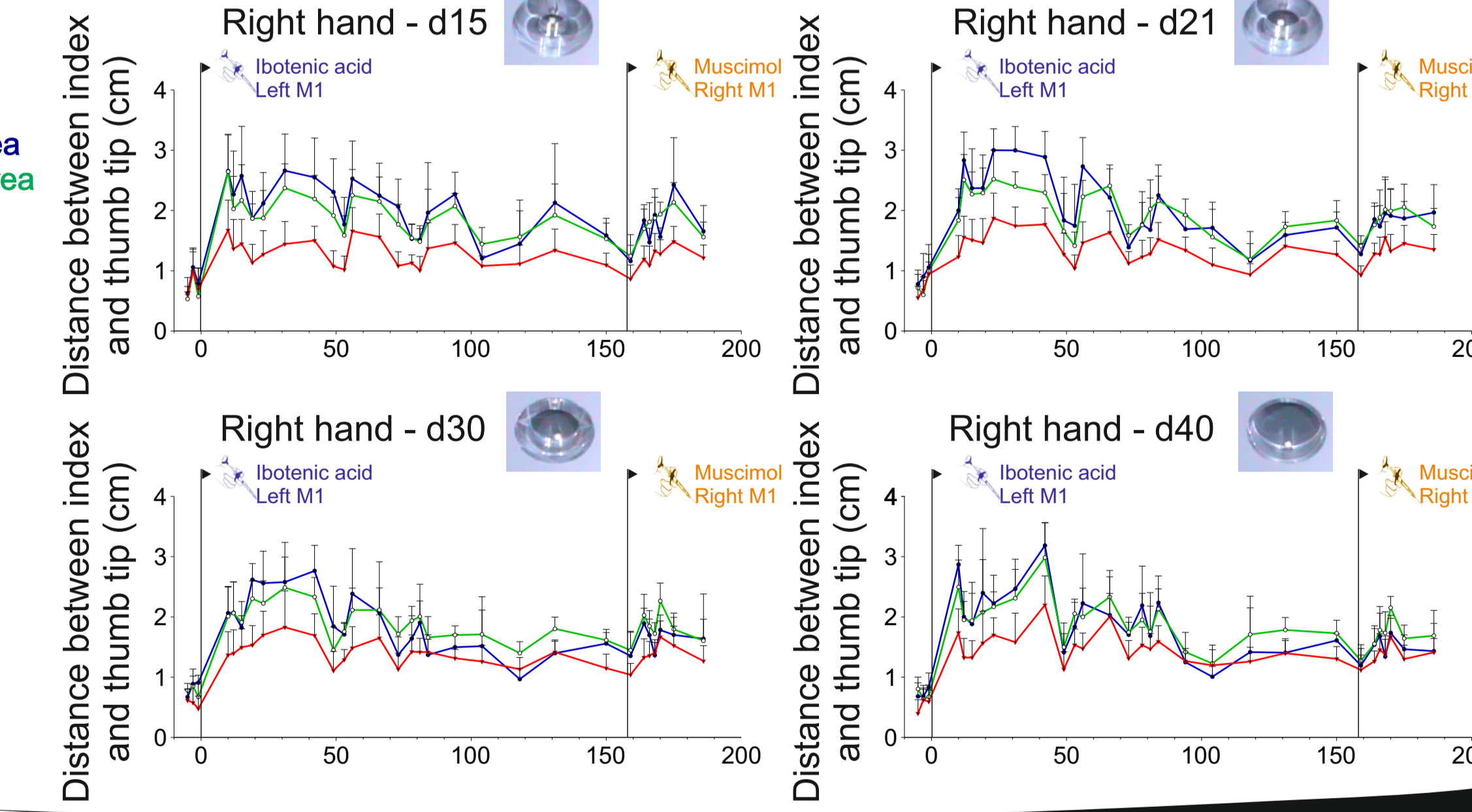
Behavioral parameters : strategies

Grasping:

Digit in well per trial



Preshaping:



Klüver board task:

- **Grasping:**
 - Subtle short-term recovery for large diameters suggesting early recovery for gross manual dexterity.
 - Paradoxically, the percentage of recovery for the fine manual dexterity was higher in small diameters than in large diameter wells.
 - Modification of the retrieval strategy by privileging, post-lesion, the use of gross manual dexterity as compared to pre-lesion precision grip, as observed for large diameters.
- **Preshaping:**
 - Subtle increase of the time needed to reach the targeted well.
 - Distance between index tip and thumb tip indicated a loss of preshaping as compared to pre-lesion period where the hand appeared already prepared from the lever release time.
 - Late tendency of preshaping reappearance around 50 days for the larger diameter wells delayed up to 105 days post-lesion for the smaller diameter wells, however never comparable to pre-lesion level.

Brinkman board task:

- Permanent M1 hand area ibotenic acid lesion induced a dramatic decrease of **score** and increase of **contact time** of fine manual dexterity.
- Fine manual dexterity requiring wrist deviation and pro-supination movement was more affected, as exhibited by lower percentage of recovery and later recovery for the horizontal slots.

Effects of a long-term inactivation of the contralesional M1 hand area:

- slight improvement of the percentage of recovery only for gross manual dexterity (larger diameters).
- increased tendency for promotion of the gross grip.
- slight improvement of the percentage of recovery only for gross manual dexterity.
- slight increase of distance between index tip and thumb tip for all diameters.
- dramatic and long term decrease of **score** for the left hand following muscimol injections.
- muscimol injections affected recovery of the horizontal slots: **contact time** and **scores**.

Discussion:

Precision grip is a complex combination of fine, precise and highly control parameters differently affected by motor cortical injury. Study of fine manual dexterity recovery could not be assessed using only one parameter of these manual tasks, each highlighting several aspects of the movement differently affected and recovered after lesion of M1 hand area: 1) modified "Brinkman board" task: precision grip performed with a wrist deviation and pro-supination position more affected following lesion than performed simple vertical position; 2) modified "Klüver board" task: strategy and efficiency to reach and retrieve small object using precision grip and gross manual dexterity with

several fingers, the last one recovered earlier but with lower percent of recovery, and the corresponding preshaping period recovering later than grasping itself. Observed functional recovery was not sustained by the intact contralesional M1 cortex, as its inactivation only modified slightly some aspects of the behavior: improved promotion of gross dexterity and altered recovery of precision grip perform with a wrist deviation and pro-supination position.