MOTOR REPRESENTATIONS OF WELL-PRACTICED HANDWRITING VERSUS NOVEL MOTOR SEQUENCES OF GRAPHOMOTOR OUTPUT: AN fMRI STUDY

M. Balas[1,2], D. Manor[3], N. Giladi[2,4], T. Kushnir[3], and A. Karni[1,3]

[1]Laboratory of Brain Imaging and learning, Haifa University, Haifa, Israel, [2]Movement Disorder Unit, Department of Neurology, Tel-Aviv Sourasky Medical Center, Tel Aviv, Israel, [3]Dept. of Diagnostic Imaging, MRI Unit, The Chaim Sheba Medical Center, Tel Hashomer, Israel, [4]Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel

Background: In humans and monkeys, extended motor practice was shown to result in the recruitment of additional M1 units into a local network specifically representing the trained motor sequence (1). It was proposed that M1 might code not just for simple, single, movements, but also for complex movement sequences. The proposal is that the representation of well-practiced handwriting sequences is effector-dependent because it relies on the activation of low-level motor areas (e.g., M1), rather than high-level ones, for fluent performance. Unpracticed writing sequences may require more activation of high-level areas (e.g., the SMA) and depend less on M1 based fluency. Neuro-imaging studies indicate that controlled, novel handwriting is associated with kinematics non-fluency and shows increased neuronal activity in brain regions that contribute to sensorimotor control and integration and attentional processes. Nevertheless, the above results are confounded by the fact that writing with the practiced (dominant) and non-practiced (non-dominant) hands was compared (2).

Aims: to study the differences between the representation of well-practiced, native hand-writing and the novel writing using the writer's dominant hand.

Method: Thirteen healthy participants performed two tasks inside a 3T (GE Excite HD) MRI scanner (Fig.1). fMRI measurement of T2* weighted BOLD contrast (TR/TE 3000/35, FA 90^o, SW 3 mm, 0.4 mm gap, FOV 22 cm, matrix 64X64 resulting in 3.4X 3.4 mm^2 in plane resolution) were acquired using 8-channels head coil. In task A, the participants wrote 18 common Hebrew words using, in a random order, either the Hebrew alphabet (Hebrew writing) or similarly constructed common Hebrew words but in the Latin alphabet (Heblatin writing). In task B, the participants completed three incomplete visual stimuli by drawing round shapes: the letters, "**O**", in the word "**O**", the numbers "**0**" in the number string 974**0**1**0,** and eyes, "**O**", in a schematic drawing of a face, in a random order. These conditions require the production of the same graphomotor output, but in different contexts. Brain activation maps were produced using the SPM2 second level (one sampled) comparison. Writing was recorded by our fMRI-compatible 2D movement monitoring system (3).

Results: Task A: while the primary motor area was activated in both handwriting types, the Heblatin writing triggered additional activations in high-level motor areas (e.g., lateral and medial pre-motor areas) that are known to be involved in the planning of new, untrained, motor sequences (Fig.2). Task B: writing zeros activated significantly more of the lateral pre-motor cortex contralateral to the writing hand as well as the ipsilateral cerebellum, compared to writing the letter. There was also more activation in the bilateral pre-cuneus, the posterior intra-parietal sulcus and dorsal occipital areas. However, there was more M1 hand-area activation in writing the letter as compared to zero. Both conditions activated the bilateral posterior superior temporal gyrus including the planum temporale, but in a non overlapping manner. Drawing eyes resulted in significantly more activation, compared to letter writing, in the lateral pre-motor and the SMA as well as more activation in M1. In contrast, letter writing activated more of bilateral parietal and occipital areas, the right superior temporal sulcus and the bilateral DLPFc.

Conclusions: Our results suggest that the motor system is highly sensitive to the context in which a given motor path is executed, as well as to the level of experience with the target movement.

Figure 1. a subject writing inside the scanner.

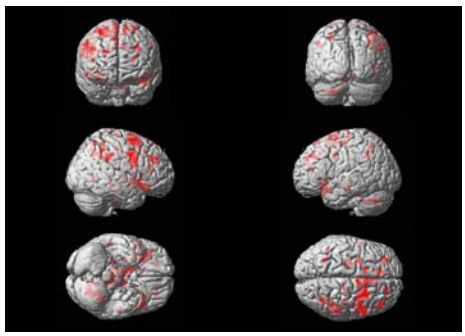

Figure 2. activation maps, Heblatin writing > Hebrew writing.

References: 1. Karni, A. et al (1995) Nature 377, 155-158.
2. Siebner, H. R. et al (2001) Eur J Neurosci. 14, 726-736.
3. Kushnir T. et al, ISMRM 14th Scientific Meeting, Seattle, WA, 2006, p. 2801.