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Expertise leads to a more efficient brain utilization: an fMRI study in professional and naïve car drivers during attention and visual-spatial tasks

Lorenzo Sani[1,2,3], Emiliano Ricciardi[1,2,3], Alessandra Papasogli[4], Riccardo Ceccarelli[4], Ferdinando Franzoni[5], Gino Santoro[5], Rainer Goebel[6], Pietro Pietrini[1,3]

[1]Laboratory of Clinical Biochemistry and Molecular Biology, University of Pisa, Italy, [2]NMR Lab, CREAS-CNR, Pisa, Italy, [3]Department of Laboratory Medicine and Molecular Diagnostics, AUO Pisa, Italy, [4]Formula Medicine, Viareggio, Italy, [5]Department of Internal Medicine, University of Pisa, Italy, [6]Department of Cognitive Neuroscience, Faculty of Psychology, Universiteit Maastricht, The Netherlands

Introduction: To achieve exceptional levels of performance, such as in sport activities, likely requires a greater ability to process information than that normally needed. Driving, for instance, is a complex behavior that requires to integrate multiple attentional, perceptual, motor and other cognitive functions. While essentially any healthy individual can learn how to drive, very few become professional car drivers, such as Formula 1 drivers. Professional car drivers compete in extreme conditions that demand, among others, higher visuospatial and motor control skills. Are these exceptional skills associated with differential patterns of brain functional organization? To test this hypothesis, we examined brain response to tasks involving attention, visuospatial integration and motor responses, in professional and naïve car drivers.

Methods: We used fMRI (GE Signa 1.5 Tesla scanner) to examine neural activity in 8 professional (mean age±s.d.=25±5 years) and 8 naïve (28±5 yrs) car driver right-handed healthy males in a 6-run block design study including randomly-alternated motor, visuospatial and attentional tasks. During the first task, participants were asked to fixate starting grid lights, and to rapidly press their right button when the red lights turned green. During the second task, subjects observed a left-sided red and a right-sided blue circles inside a billiard table-like frame. Two red and two blue balls moved randomly within the "billiard", and participants had to press the left or the right button when a ball run inside the color-matched circle. This task randomly alternated among three levels of difficulty, as ball speed increased. A multiple regression analysis was used to identify task-related brain regions, and unpaired T-tests were used to determine differences between the two groups.

Results: Both professional and naïve car drivers showed similar performances during the motor reaction task (mean reaction time±s.d.=192±34 ms professional/193±35 ms naïve; difference p=n.s.) and the "billiard" tasks (average correct responses >80% across trials in both groups; difference p=n.s.). During the motor reaction task, as compared to professional drivers naïve subjects recruited significant larger areas of left motor, right dorsolateral prefrontal and inferior frontal cortex, and bilateral supplementary motor and posterior parietal regions. During the visual-spatial "billiard" tasks, functional differences between the two groups became significant only at the highest level of difficulty: naïve subjects showed greater activations in the left motor and supplementary motor areas, left posterior parietal, right cingulate, inferior frontal and supramarginal cortex as compared to professional car drivers.

Conclusions: Despite similar levels of performance, naïve and professional car drivers showed different patterns of brain response to the same tasks. Specifically, professional drivers demonstrated a significantly lesser recruitment of task-relevant brain areas, thus indicating an increased efficiency in attentional and sensory information processing. These results complement the studies reporting that during distinct cognitive tasks older as compared to younger individuals recruit larger cortical areas to maintain performance (1,2). Altogether, these results further support the hypothesis that a higher level of cognitive ability is associated with a more efficient recruitment of task-related brain areas.

References: 1. Freo et al., Am J Psychiatry 162:2061-70, 2005
2. Cabeza, Psychol Aging 17:85-100, 2002