Declan Grindrod

7th May 2024

Journal Club

It’s not just in your car: functional and structural correlates of exceptional driving skills in professional racers

Introduction

Why this paper?

- Personal interest
- PhD interest
- Multiple useful citations for further reading
- Carried out by researchers I’m trying to contact

🇬🇧 *Congrats Lando!* 🏆 🇺🇸

Introduction

What's the paper about?

- Brain structural and functional differences between professional racing-car drivers and naïve individuals
- Naïve: had no history of practicing any sport at an amateur or professional level
- Professional: actively participating in a professional racing tournament (F1, F3, World Series…) at the time of the study with a minimum of 4 years of expertise in both amateur and professional racing
- 11 naïve / 11 pros (100% Male, 100% right-handed)

Introduction

Hypotheses

1. Pros would show distinct patterns of brain response and regional interaction compared to naïve individuals during a passive driving task

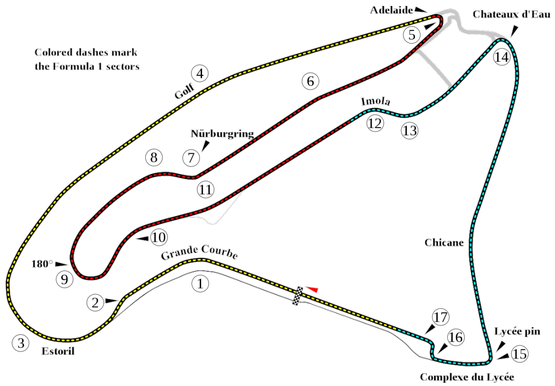
2. Structural brain substrates in Pros would differ from those in individuals with ordinary driving experience

3. Expertise in racing may be associated with specific anatomical and functional changes in the brain, particularly in areas related to motor control, spatial navigation and high-speed driving behaviour.

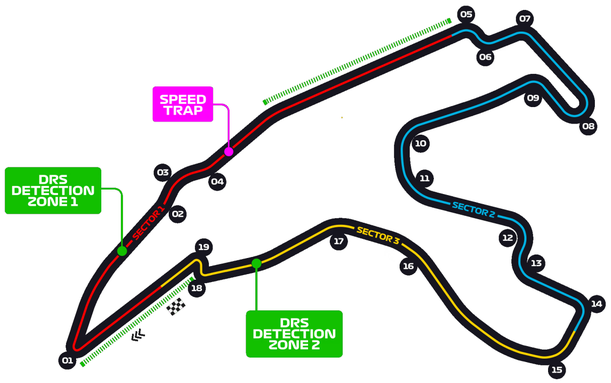
Experimental Design

Task

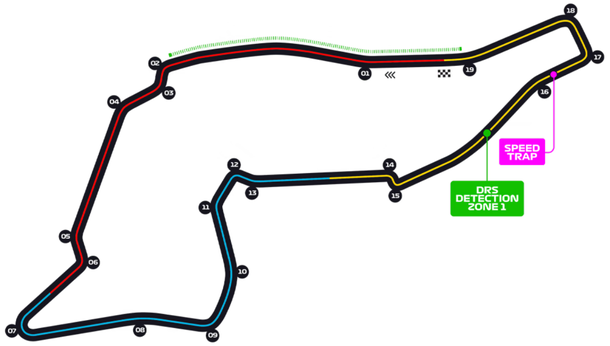
- While inside the MRI scanner, participants watched video clips of F1 cars being driven around four circuits, recorded from the on-board camera



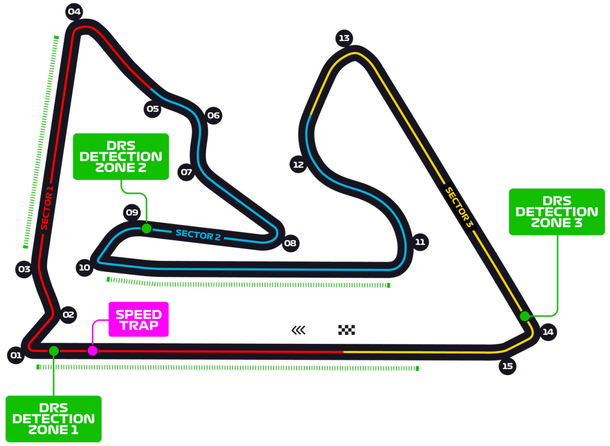
Magny-Cours 🇫🇷



Spa-Francorchamps 🇧🇪



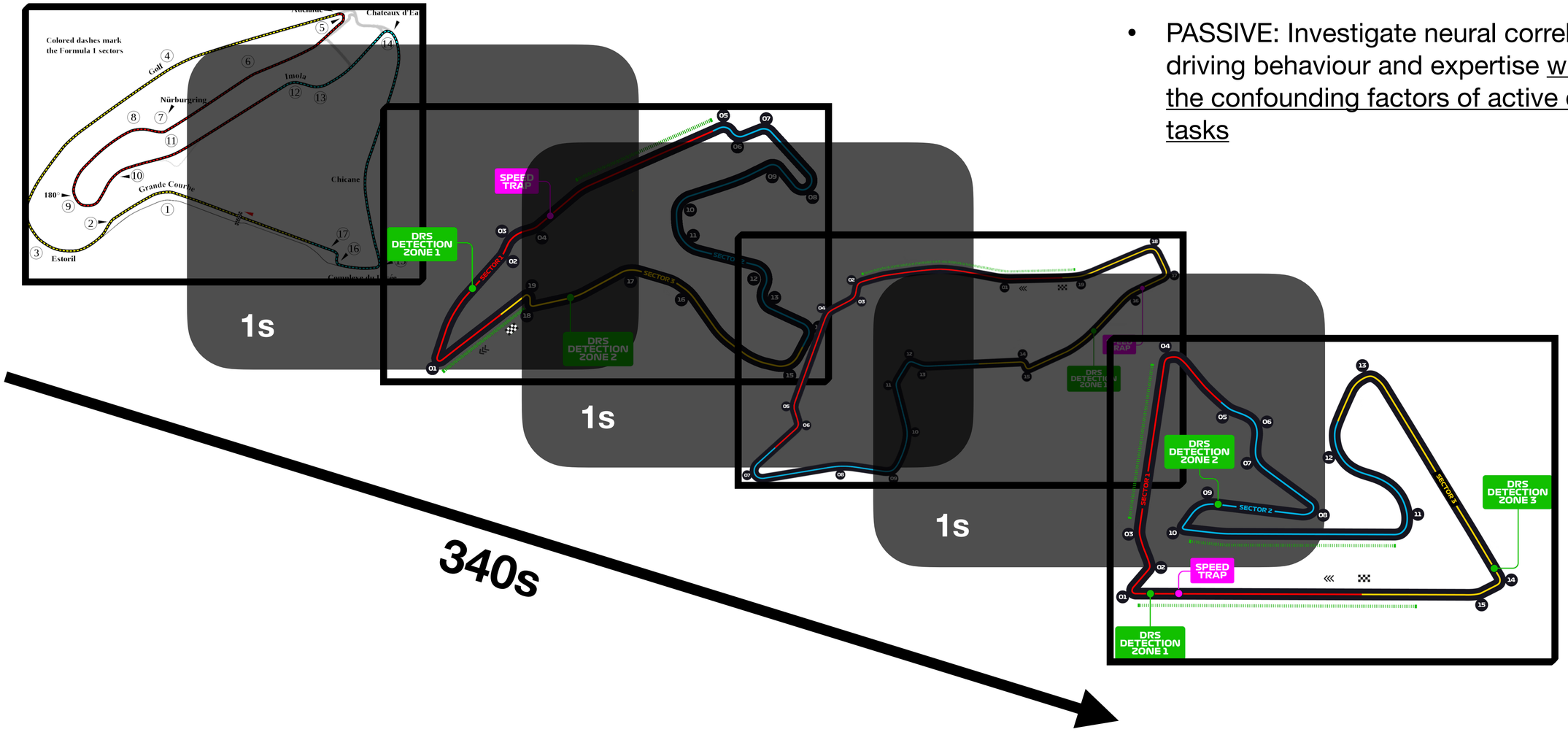
Imola 🇮🇹



Sakhir 🇧🇭

Experimental Design

Task duration and instructions



“Observe the driving scenario as if you are the driver”

- Continuous stimulation, simulating natural driving conditions vs with interruptions
- PASSIVE: Investigate neural correlates of driving behaviour and expertise without the confounding factors of active driving tasks

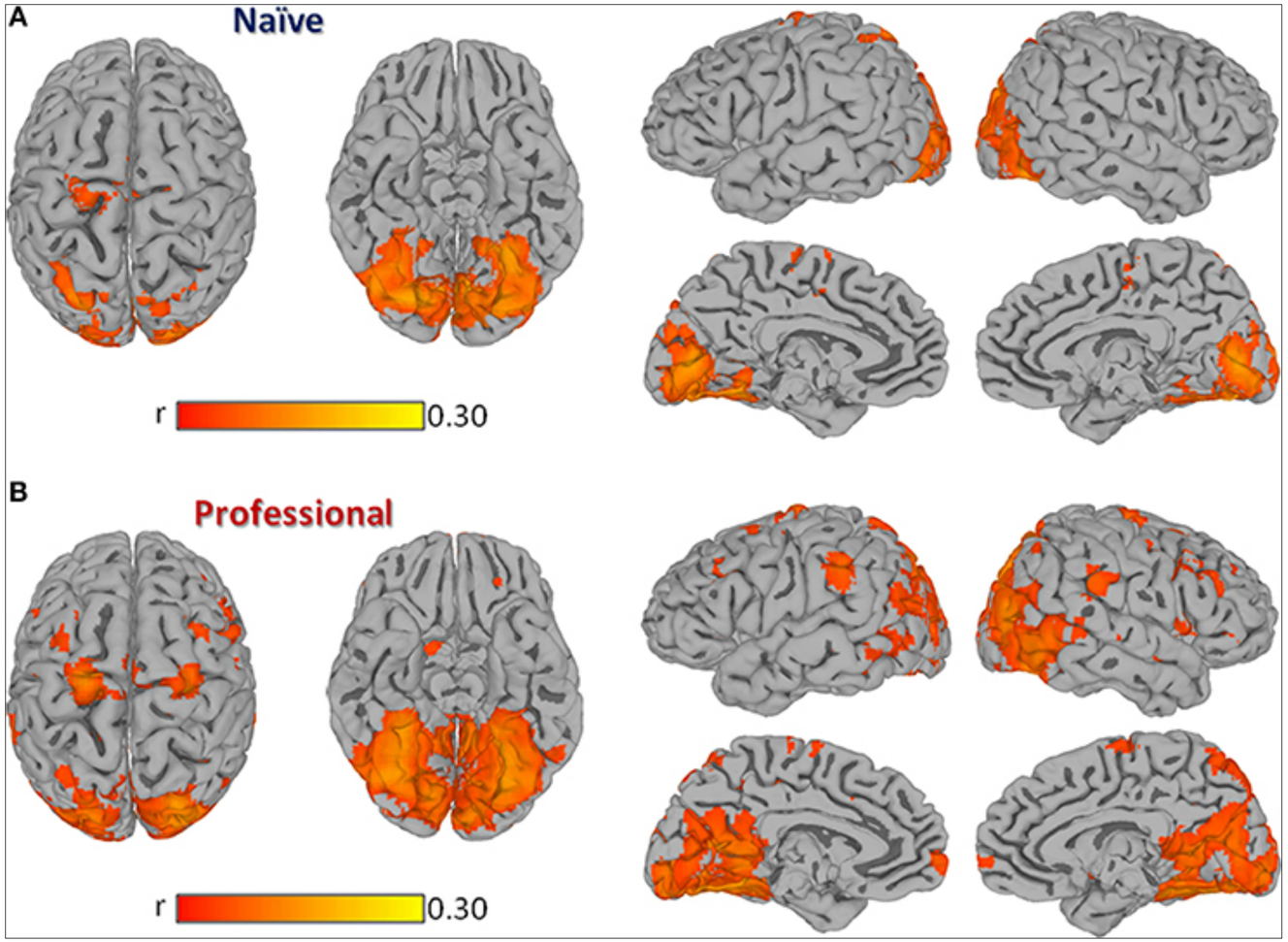
Methods

Tools and Analysis

- **Structural and functional MRI** (AFNI, SUMA, 2mm^3 voxels)
  1 pro and 2 naïve participants' scans were excluded due to technical/artefact issues
- General Linear Model (GLM) not suited to naturalistic (passive) viewing
  → Inter-Subject Correlation (**ISC**) + Pearson's coefficient for each possible in-group pairing
  → 45 Pro and 36 naïve correlation maps + whole-brain statistical comparison with minimum threshold > 30 voxels
- **FC analysis**: 45 cortical + 45 subcortical regions using Eickhoff-Zilles Atlas
- Voxel-Based Morphometry (**VBM**) for differences in brain structure, grey matter density
  1 naïve participant was excluded due to artefact issues

Results

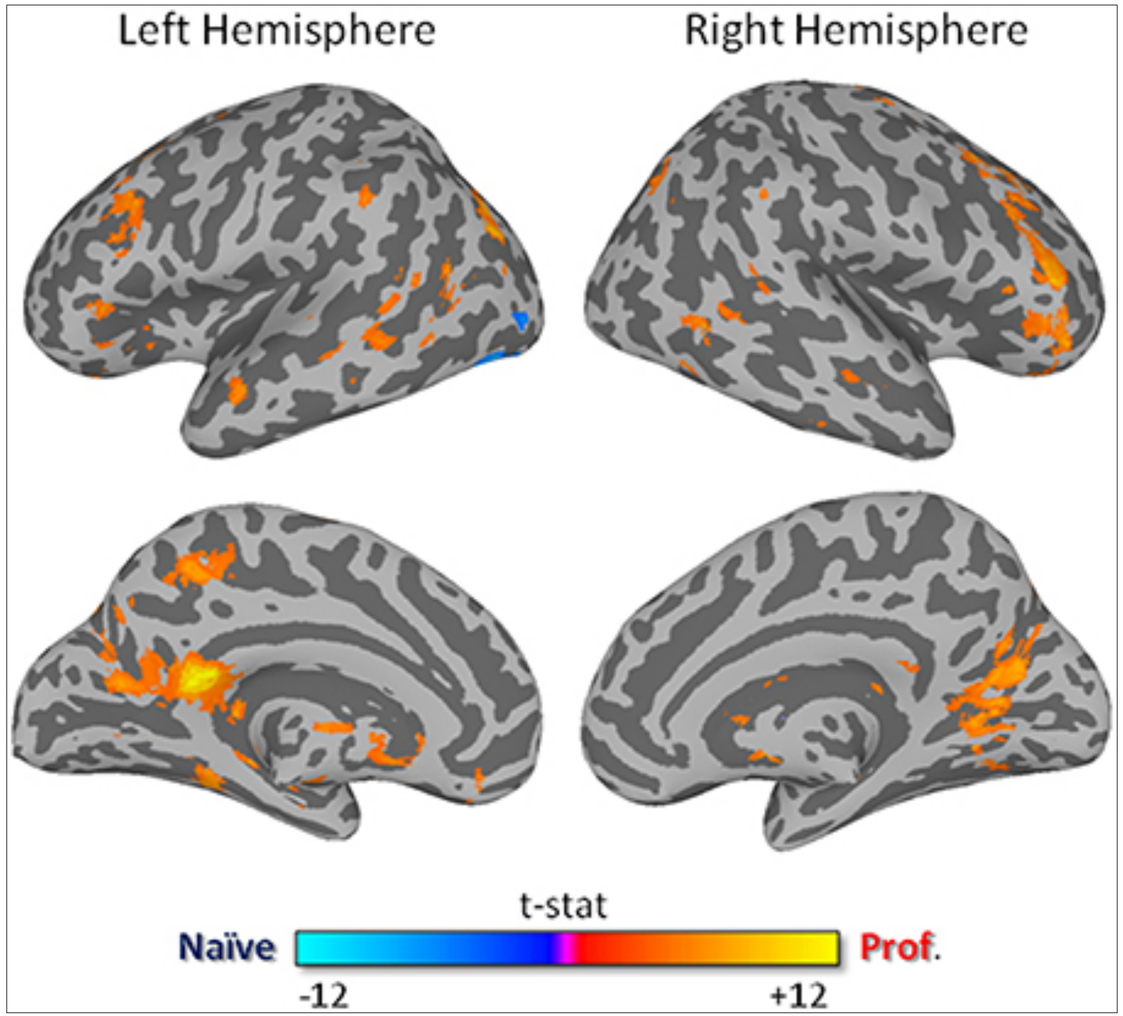
Figure 1: ISC within-group



- Both groups exhibit significant responses in areas related to visual processing, attention, and motor control, including the visual cortex, precuneus, cingulate and parahippocampus.
- Pros show additional significant correlations in regions like the inferior parietal, temporal, and frontal cortex, suggesting neural adaptations related to driving expertise.

Results

Figure 2: ISC between-group

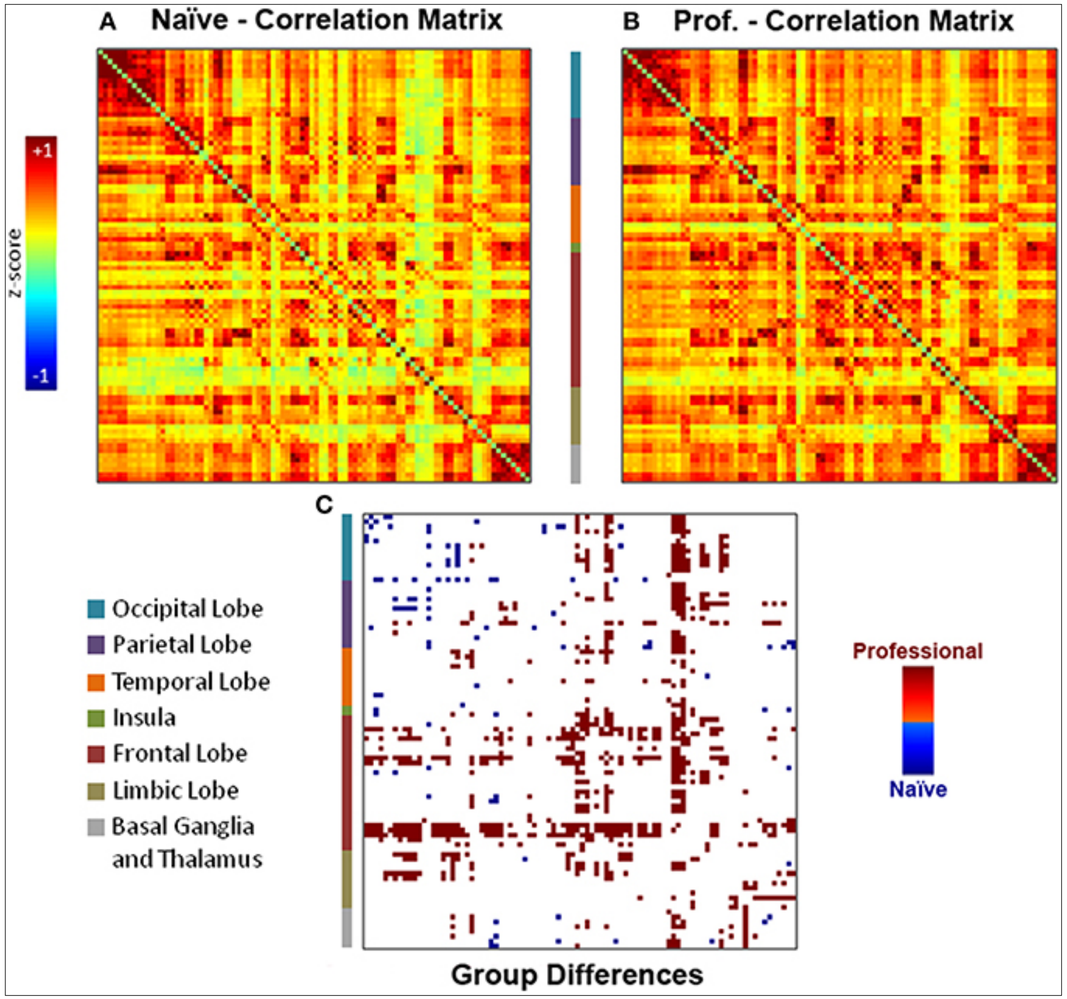


- Varying levels of synchronisation and similarity in brain activity patterns during the passive driving task
- Clear emphasis on the group-specific brain responses: indicates how professional drivers exhibit different patterns of brain activity compared to naïve drivers
- Neural activity variations potentially linked to driving proficiency and expertise.

(Higher t-values indicate stronger evidence of significant differences in ISC values)

Results

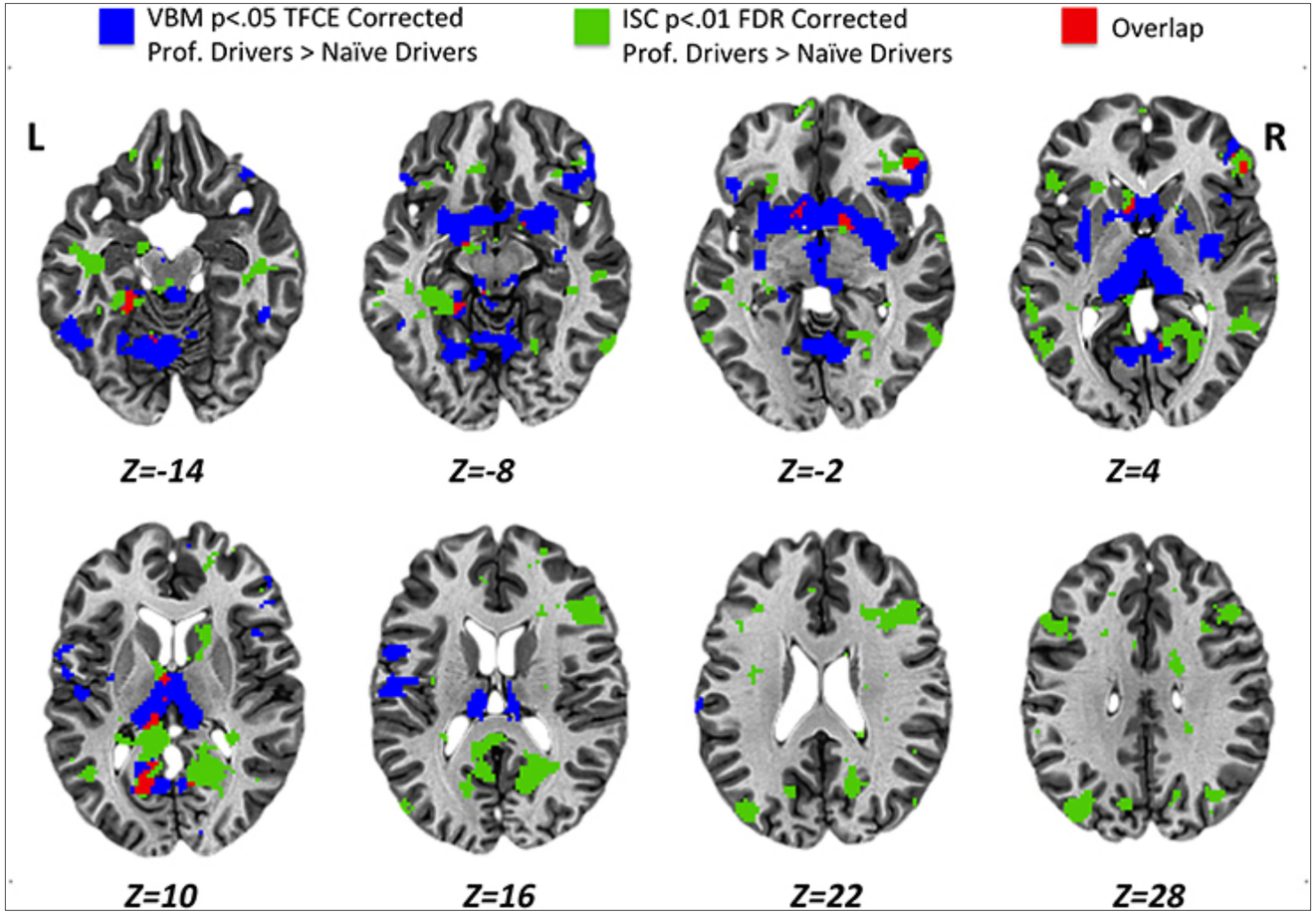
Figure 3: FC correlation matrix



- For the lobes and ROI that show no linear correlation in the naïve population, we see a positive correlation in the Pros (Fig.3A, 3B)
- These specific differences in ROI activity correlation are visible in Fig.3C.
- Naïve drivers show increased activity in the Occipital and Parietal lobes, linked to visual processing and spatial awareness. Suggests that this group are focusing more on managing visual stimuli.
- Pro drivers show increased activity in all other studied ROI. Suggests enhanced processing of execution and motor coordination/planning.

Results

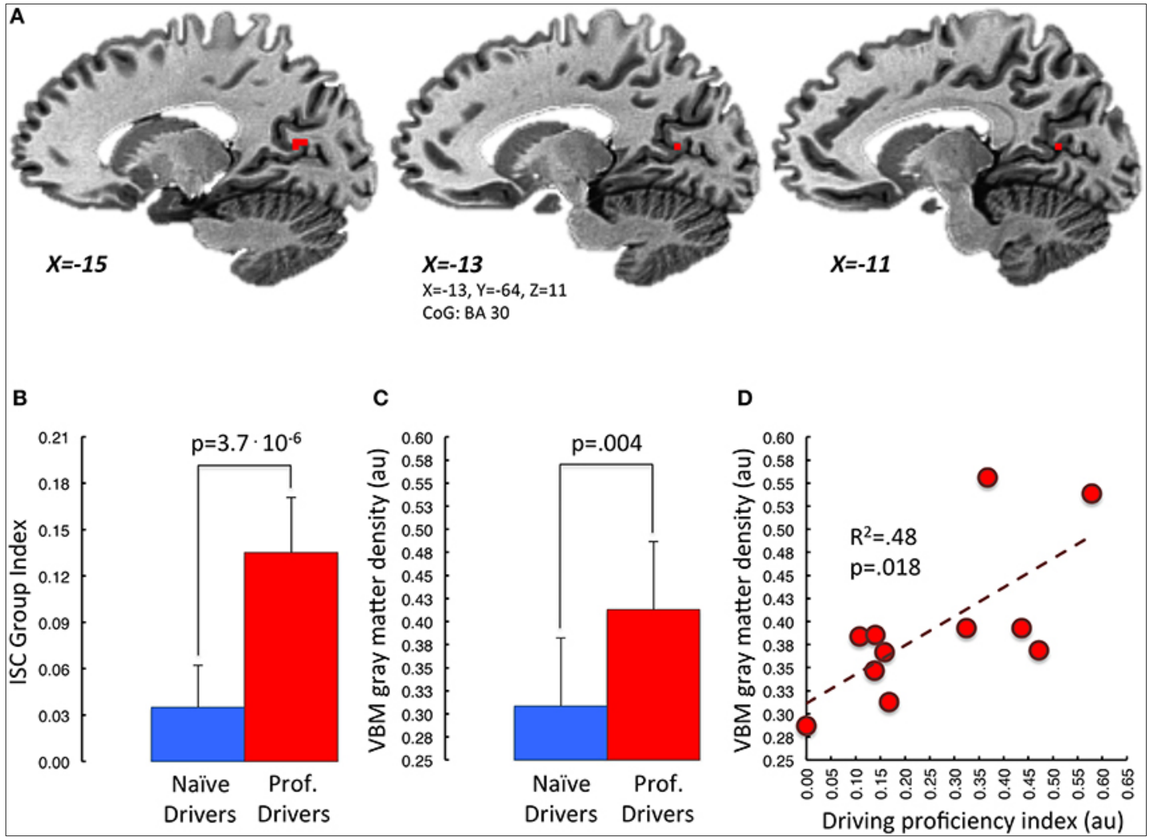
Figure 4: VBM+ISC



- Pros show increased synchronisation in regions involved in motor planning, motor control, decision-making, and cognitive processing.
- The increased grey matter density in Pros is observed in regions related to sensory perception and motor function (Thalamus), motor control and learning (caudate), **spatial navigation/learning and memory (retrosplenial cortex)**, visual processing (Inferior temporal gyrus, Fusiform gyrus)
- These structural adaptations suggest neural specialisation related to driving expertise

Results

Figure 5: Grey matter density/performance



- Pros show increased ISC activation patterns (Fig.5B) and increased grey matter density (Fig.5C) in the retrosplenial cortex (in red, Fig.5A)
- Retrosplenial cortex is involved in spatial navigation, spatial learning and spatial memory (ability to create observer-independent maps of a geographical area)
- Fig.5D plots the VBM as a function of driving proficiency (i.e. the number of podium finishes relative to the total number of races participated)

Discussion

Good	Bad
MRI	1.5T
Access to pro drivers	Didn’t actually get them to drive
100% right-handed	100% right-handed
	Small samples
	Male only study
	Supplementary Material missing

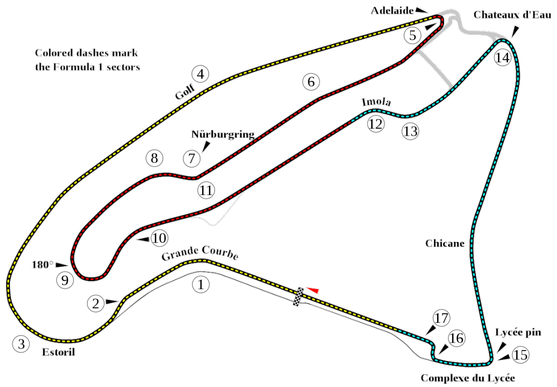
What could be next?

- Inclusion of longitudinal assessments to study neuroplastic changes over a career, with focus on retrosplenial cortex as data on number of podiums increases

- Female participants (F1 Academy, F3)

Discussion

Tracks



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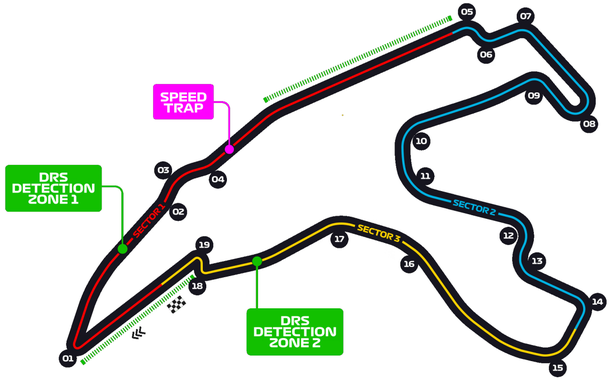

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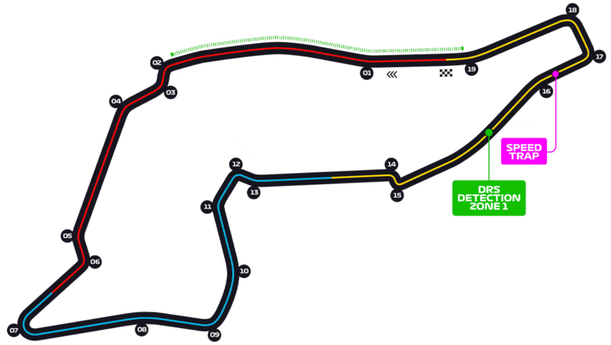

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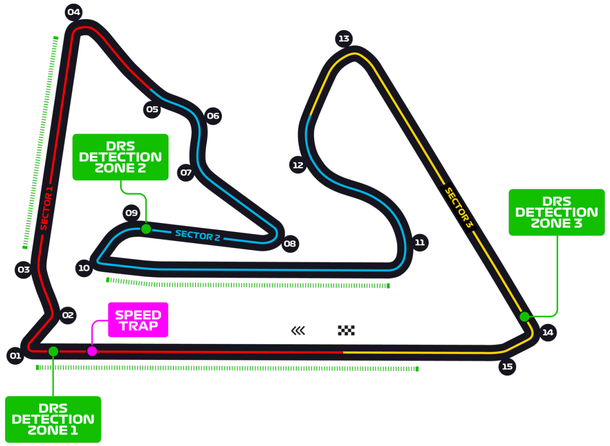


Sakhir 🇧🇭

↻ *F1: 1991-2008*

↻ *F1: 1950-2024*

↺ *F1: 1980-2024*

↻ *F1: 2004-2024*

- Three clockwise circuits versus one anti-clockwise circuit
- No mention of random video presentation order
- Were all videos recorded in the same quality?

Discussion

Tracks

> “[T]he **ability to detect and react to information** under lowered alertness conditions **might be more impaired on the left than the right side of space.** This evidence derives mainly from right-handers being assessed in computer and paper-and-pencil spatial attention tasks. However, **there are suggestions that left-handers might show impairments on the opposite (right) side compared to right-handers with lowered alertness**, and it is unclear whether the impairments observed in the computer tasks have any real-world implications for activities such as driving.”

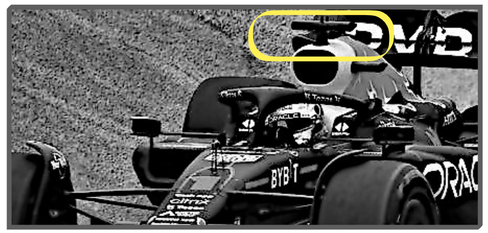
Chandrakumar, D., Coussens, S., Keage, H.A.D. *et al.* Monotonous driving induces shifts in spatial attention as a function of handedness. *Sci Rep* **11**, 10155 (2021). https://doi.org/10.1038/s41598-021-89054-1

Discussion

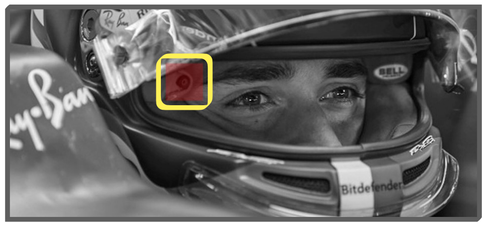
Recording angle

To increase passive sensation of immersion

On-board from T-Cam



On-board from Visor cam



Thank you! 🏆🏎️

Bernardi G, Cecchetti L, Handjaras G, Sani L, Gaglianese A, Ceccarelli R, Franzoni F, Galetta F, Santoro G, Goebel R, Ricciardi E and Pietrini P (2014) It's not all in your car: functional and structural correlates of exceptional driving skills in professional racers. Front. Hum. Neurosci. 8:888. doi: 10.3389/fnhum.2014.00888