04 How Does the Human Brain Make Sense of the External World?

Fiona Newell

We live in a multisensory world and our senses are constantly bombarded by stimulation from the sounds, sights, smells and tastes from the outside environment. The human brain is continually challenged with the task of maintaining a coherent perception despite this ongoing cacophony of sensory stimulation. Our brain has the remarkable capacity to inhibit irrelevant sensory information and merge relevant information, from across multiple senses, to allow us to appropriately engage with the world. It appears to do this by organising sensory information in a task-specific manner. For example, a specific region of the brain is involved in object perception whereas another underpins the perception of the object's location. My research tries to understand how the brain achieves the seemingly incredible feat of perception.

Together with my research team in the Institute of Neuroscience, our approach takes a cognitive neuroscience perspective and involves different methodologies, from psychophysical studies, to neuroimaging using Magnetic Resonance Imaging or EEG. We also study unusual perceptual conditions, such as synaesthesia, to help elucidate the links between brain function and phenomenological experiences. This broader research programme is supported by on-going cross-disciplinary and cross-faculty collaborations with other research groups within Trinity, such as Prof Carol O'Sullivan in Computer Science, Prof Kevin Mitchell in Genetics, and Prof Rose Anne Kenny in Medicine.

The wonders of human perception — We investigate common, everyday perceptual tasks that are seemingly effortlessly performed every minute of our lives, yet the behavioural and brain processes underpinning those tasks are not yet well understood. Taking face perception as an example, I ask how does the brain solve the problem of identifying familiar faces from the thousands of faces we have encountered in our lives? Even the best computer systems often fail to recognise images of familiar faces that are altered by incidental changes such as lighting, viewpoint, hairstyle, ageing, but such changes do not appear to affect the performance of the human brain. At the same time, face perception must remain sensitive to momentary changes in eye gaze and expressions, so that we can perceive the attention and intentions of others (Fig. 1), and link those momentary changes with other sensory information, such as sound for speech perception. I gain greater insight into how the brain works by also investigating when these processes break down: for example, prosopagnosia is a condition associated with an inability to recognise familiar faces, including family and friends. We try to understand the basis of this specific perceptual condition using several approaches, but more recently by comparing the eye movements of a prosopagnosic patient observing a face with those of persons who can recognise faces (Fig 2).

The knowledge I have acquired to date on human perception has been applied in a number of ways. Our recent research has used Virtual Reality technology to build a serious game intervention that improves perceptual function in older adults (see Fig 3). After just a few sessions of playing the game, we found observable changes in the brain of older adults (see Fig 4). As part of an EU-funded H2020 project, entitled 'WeDraw', and in collaboration with IIT in Italy, UCL in UK, as well as pan-European games companies, we are developing technology that helps both sighted and visually impaired children to acquire geometrical and arithmetic concepts. Our aim is to go beyond visual examples, and incorporate multiple sensory systems to support this learning in children in a fun and engaging way.

Fiona Newell received her BA from Trinity and PhD from University of Durham, UK. She joined the School of Psychology in Trinity as a lecturer in 2000, following post-doctoral positions at Cambridge, UK, Weizmann Institute, Israel; and Max-Planck Institute, Germany. She is now Professor of Experimental Psychology based in the Institute of Neuroscience. She has published almost 100 articles in peer-review journals, and acts as associate editor for leading journals. Her research interests lie in human sensory and perceptual processes.
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Fig 1. How does the brain recognise the faces, as well as the intention and attention, of others?

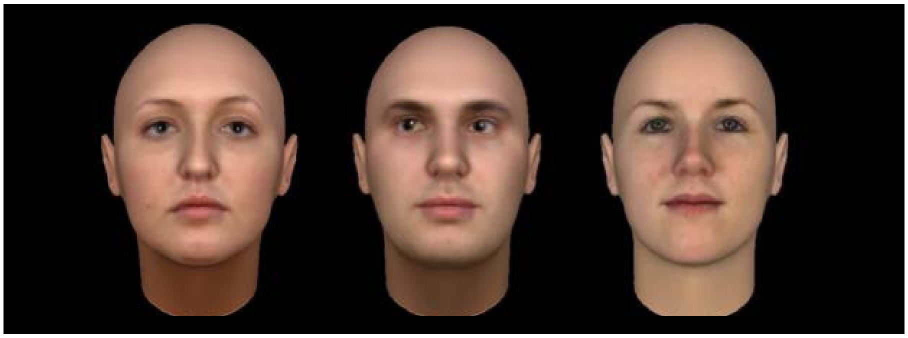


Fig 2. Typically, when we encounter a new face, we tend to scan all features but especially the eye region of a face (bottom left). In contrast, someone with prosopagnosia typically spends more time looking at other facial features, such as the mouth (bottom right), that have more to do with speech than face perception.

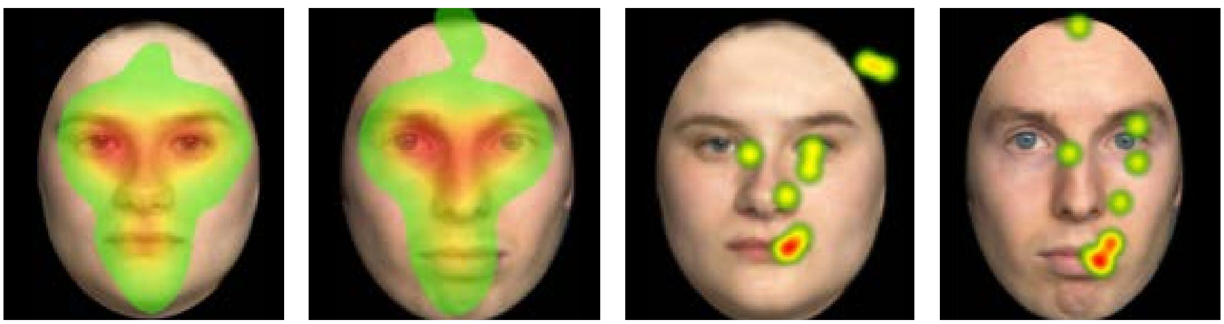
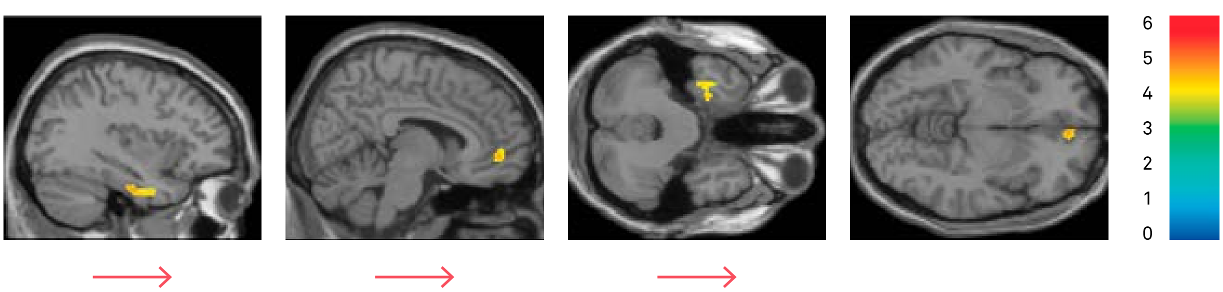


Fig 3. For older adults, memory for novel objects is enhanced if encountered within images of familar (e.g. left) than unfamiliar (e.g. right) environments.

Fig 4. The structure of specific regions within the brain of an older adult can increase with practice on a serious game.



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