Sociability is a fundamental part of the human story, with relationships comprising an enormous part of our lives. Our ability to understand and respond appropriately to social cues is fundamental to our ultimate success as friends, spouses, colleagues and parents. However, the ways in which our brains represent and process information during even basic interactions remain mysterious.

NEUROSCIENCE OF SOCIAL INTERACTION
The human brain has been described as being hard-wired for socialising, given the large areas given over to social cognition processing. What we know about the brain relies on clinical observation, autopsy, animal studies and neuroimaging. Much remains unknown about the brain due to its incredibly complex make-up, consisting as it does of billions of neurons and trillions of synapses. Luckily, brain scanning techniques provide us with vital insights.

Humans are innately sociable mammals. However, almost all of our understanding of the neural basis of social interaction has been carried out with individual participants, limiting our knowledge of how our brains react to other humans. Joy Hirsch, Professor of Neuroscience at the Yale School of Medicine and University College London, has embarked on a truly pioneering research programme using new neuroimaging technology to study the human brain as it interacts with others.

Two brain neuroscience: understanding our social selves

Two-brain neuroscience is focussed on understanding the neural basis of real-time, dynamic communication between two people.
involve brain activity that is not seen during non-interactive, isolated behaviour.

The Interactive Brain Hypothesis states that interpersonal interactions between people involve brain activity that is not seen during non-interactive, isolated behaviour.

New tools for a new era
A key hurdle is the methodology of studying two brains—what type of approach could allow scientists to deduce neural activity in two people at one time? As it turns out, a groundbreaking approach to social cognition requires the use of groundbreaking technology, known as functional near-infrared spectroscopy (fNIRS).

Professor Hirsch has been involved in developing and refining the use of fNIRS, allowing researchers to test the Interactive Brain Hypothesis in naturalistic settings. fNIRS is grounded in medical physics and relies on the detection of local changes in levels of oxygen and deoxyhaemoglobin in blood indicating underlying neural activity. In a similar vein to fMRI, fNIRS detects changes in blood oxygen as a proxy of brain activity in specific pre-defined areas. However, unlike fMRI, fNIRS does not require isolation in a scanning bore and can tolerate small amounts of head movement. Detectors of the fNIRS signal are head-mounted and the caps can be worn sitting, standing or walking.

The Interactive Brain Hypothesis
Prof. Hirsch’s studies are centred around a new theoretical framework, known as the Interactive Brain Hypothesis. This hypothesis states that interpersonal interactions between people involve brain activity that is not seen during non-interactive, isolated behaviour. At its core, it is the understanding that human-to-human interactions elicit unique responses in our brains.

In support of the hypothesis, recent studies taking place in Prof. Hirsch’s group have shown that pairs of individuals—referred to as ‘dyads’—partaking in a poker game show activity in areas traditionally associated with empathy. The same areas are not activated when an individual plays similar games against a computer, highlighting the special nature of real-life interaction between humans.

Moreover, the team have also shown that the real-life eye-to-eye contact between two participants activates different areas of the brain than two people simply focusing on a photograph of a face. Intriguingly, this finding showed that there was unique activation of areas including parts of the brain involved in language, referred to as Broca’s and Wernicke’s areas. Broca’s area—a region in the frontal lobe—is well established as being central to language production, whereas Wernicke’s area—a region in the temporal and parietal lobes—is key to comprehension.

Language is perhaps the best characterised and most studied of our social abilities, with areas in the brain well established to be localised for understanding and generating language. The development of language abilities separates us from our closest evolutionary cousins, highlighting its fundamental importance as a species.

Prof. Hirsch’s most recent findings in support of the Interactive Brain Hypothesis have illuminated how our brains function during this very human behaviour of talking and listening. In this study, dyads were shown to have increased brain activity when they were taking part in dialogue, as opposed to monologue, specifically in Wernicke’s area, which

The human language system includes specialised regions for production (talking) and reception (listening). Intriguingly, these areas are also activated during eye-to-eye contact between two people.

What made you first want to study this exciting new field?
I am an academic explorer, and have aggressively pursued the question of neural systems that underlie interaction between two people because these are our most important functions, little is known about them, and the questions challenge our theoretical frameworks and technology. I am drawn to questions without answers.

In the face of your fNIRS findings, are social neuroscience studies less reflective of how our brains really work than we thought?
fNIRS opens a window of opportunity to investigate the dynamic brain in real-time. Investigations of single-brain organisation and processes using conventional static neuromaging technology have revolutionised our understanding of basic brain mechanisms. The new neuroscience of two individuals during interaction has the potential to be the next “quantum leap” in social neuroscience. I anticipate that these nascent investigations will lead to new insights into interpersonal conflict, and communications between individuals who are members of different social or economic groups/cultures. We value social diversity and yet little is known about how to implement these social policies into action. The new neuroscience of two person interaction has the potential to address this knowledge gap.

Could these new tools help to understand neurological disorders where there might be a problem with communication, for example in autism spectrum disorders?
In addition to our current and ongoing studies of typical interpersonal interaction between individuals, we are currently studying social dynamics in autism spectrum disorders. ASD. The hypothesis is that neural specialisations for interpersonal interactions are altered in ASD. Clinical applications for dual-brain fNIRS are an emerging new frontier. Communication problems are common symptoms in many psychiatric disorders such as depression, anxiety, PTSD, delusions, and schizophrenia, and dementia, as well as normal ageing, and may impact neuronal systems engaged during social interactions. These future directions are made possible by the development of a basic theoretical framework and computational as well technological tools.

Do you think robots will ever be able to provide the same brain responses as fellow humans?
That would be a great research question.

Looking to the future
Prof. Hirsch’s work has taken what is known about social cognition from standard testing and taken it to the next level. The aim of her programme is to advance understanding of social interaction, including cognition and social emotion, gesturing, eye contact and language, in an exhilarating new age of neuroscience research. Two-brain neuroscience promises to get to the heart of our social selves and the essence of what makes us human.

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Collaborators

Bio
Joy Hirsch is a Professor of Neuroscience at Yale School of Medicine in the Departments of Psychiatry, Neuroscience, and Comparative Medicine where she is the current Director of the Brain Function Laboratory, and Sr. Investigator in the Haskins Laboratories, New Haven, CT USA. She is also Professor of Neuroscience in the Department of Medical Physics and Biomedical Engineering at University College London, London WC1E 6BT, UK.

Research objectives
Prof. Hirsch aims to develop “two-brain Neuroscience”, an exciting extension of the field to understand the neural reactions of two individuals during communication and interpersonal interaction.