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The Evolution of Cognitive Neuropsychology

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Abstract

Cognitive neuroscience is a rising and promising new scientific field that consolidates the meta-theoretical qualities of a transformative point of view with the methodological rigor of neuroscience. Cognitive neuroscience, the study of brain and behaviour connections, has since quite a while ago endeavoured to map the brain. The discipline is thriving, with an expanding number of useful neuroimaging studies showing up in the scientific literature day by day. In this article, we briefly review the past and present state of cognitive neuroscience, and what we anticipate as the future bearings of the discipline.

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Introduction

Cognitive neuropsychology is an approach that aims to understand the human cognition by combining information from behaviour and the brain. This discipline has a long history dating back to the Ancient Greeks. Modern landmarks in cognitive neuropsychology include: Golgi's method of staining brain tissue, Cajal's discovery that the nervous system was made up of neurons, Helmholtz's discovery that neurons communicate with each other via electrical signals, Gall's notion that skull protuberances resulted from underlying active cortical regions, Broca's post-mortem study of localization of motor functions in dogs. Therefore, this essay particularly focuses on the emergence of cognitive neuropsychology from a historical perspective and what the future holds for this discipline.

Historical Perspectives

The main interest of research was the brain in the seventeenth century. The first popular documented case of brain damage by Edwin Smith, described 48 brain injury cases with their significant consequences and their treatments. Thomas Willis (1664), the founder of clinical neuroscience, explained the link between brain damage and specific behavioural deficits (Andreason, 2005). Harlow (1848) stated a patient who showed a dramatic change of personality following a traumatic skull injury that damaged a specific portion of the prefrontal lobe involved in personality change. Freud described the normal and abnormal phenomena of cognitive mechanisms and that could be explained through meticulous study of brain systems (Andreason, 2005). For instance, the common symptom of schizophrenia is hallucination. Understandable neural mechanisms could potentially explain many things about brain dysfunction in schizophrenia.

In the eighteenth century there was an increased focus on reflex action and spinal cord. Hall (1857) stressed the importance of reflexive actions and explained that all muscular functions, except respiration, cardiac activity and irritability, depend on reflexes which are controlled by the spinal cord. Sherrington (1952) then described the mechanism of spinal reflex which explained that all higher functions of the brain are of a reflex nature. For example, Pavlov explained in his classical conditioning that dogs started to secrete digestive fluids before food came in their mouth without conscious thought (Price, 1999). A study by Helmholtz (1894) and Cajal (1934) about speed of information transmission in nerves established the neuron doctrine which states that the brain consists of individual neurons that communicate with each other. Golgi (1926) then discovered a staining technique that made neurons visible. These discoveries made the neural process very clear; how neurons transfer information to the brain, how neurons look, and the speed of the neural transmission etc. which has opened many doors to understand the brain process well and help further research and scope.

In the nineteenth century Gall (1828) and Spurzheim (1832) proposed the idea of localisation of functions in the brain, against the equipotentiality theory which explained that the brain functions as a whole with all parts having an equal significance. However, Flourens (1867) and Müller (1858) were strong defenders of the brain equipotentiality theory on the basis of empirical studies. They argued that as long as the brain lesion was not too large, the remaining tissue could take over. Bouillaud (1881) explained the localisation of language in the frontal lobes, Broca (1880) discovered the localisation of speech in the left frontal lobe and Wernicke (1905) discovered the localisation of language understanding in the rear part of the left hemisphere (Banich, 1997).

These series of findings in the nineteenth century convinced an increasing number of investigators that brain equipotentiality theory was wrong and had to be replaced by the localisation theory which states that mental functions are localised in specific parts of the brain. Therefore, localization of brain function is important for neuroscience because complex brain functions can be broken down into simpler, more general processes which can be correlated with their simpler less complex behavioural processes .These components can then be localized in the brain and studied in relative isolation.

In the twentieth century scientists increasingly managed to extract information from a working brain. One of the first techniques used was single cell recording but unfortunately this technique involved brain surgery and the insertion of electrodes into the brain, consequently its use with humans was very limited. Then Berger invented the Electroencephalogram (EEG) in 1924 and this contributed towards the systematic study of human brain's electrical activity. EEG-recordings allow researchers to pick the summed electrical activity of groups of cells non-invasively. The recordings allow researchers to detect some conditions, like epilepsy, and to discover different stages in sleep (Raichle, 2009).

The fMRI was developed by Sir Peter Mansfield at the University of Nottingham in 1980. This technique is based on changes in the magnetic properties of atoms and observing the activity of atomic nuclei. The PET scan was invented in 1973 by Phelps. PET-scanning allows researchers to see which brain areas require extra blood during performance of tasks by tracing a radioactive substance injected into the blood. Eventually these brain imaging techniques became available which were termed non-invasive techniques and have allowed researchers to measure brain activity while participants are performing mental tasks, this created a new research field in the cognitive neuroscience.

Current and Future Perspectives

Currently, cognitive neuropsychology is focused on the application of non-invasive methods, in experimental animals, to study higher cognitive functions such as face recognition, attention, working memory etc. The most prominent of these methods is the recording of the activity of single neurons from awake animals as they perform experimental tasks. The most recent study based on fMRI by Farb., *et al*. (2013) explains that a mindfulness based stress reduction course altered BOLD (blood oxygen level development) responses during attention to breath paradigm.

Presently, researchers in cognitive neuroscience are seeking to create machines as adept as human (or more so) and researches are attempting to figure out the computational basis of human cognition and how the brain actually carries out its computations which is called computational modelling (Colheart, 2002). Almost all contemporary computational modelling research is based on the idea of neural networks, or more accurately artificial neural network (ANN) with basic interest to explain neural mechanism of cognitive process.

The future of cognitive neuroscience lies in the development of brain imaging techniques, perhaps in combination with other electro-physiological techniques. Functional brain imaging methods analyse the neural basis of brain functions. Therefore, "mind reading" is certainly beyond the possibility of brain imaging, and it can only be wondered if it might become possible in near future. Neuroimaging provides a safe way to examine the workings of live brains but can only produce images on millimetre scale resolution.

Unfortunately, current neuroimaging studies, with their focus on structure-function relationships, are difficult to combine with network models. For example, new structural (DTI) and functional (rs-fcMRI) connectivity methods in MRI cannot reveal relationships between neurons or small groups of neurons as simulated in artificial neural networks. However, it can be expected that joining technologies combined from the nano-scale could define a remarkable progress in cognitive neuroscience in the future.

In the last few decades, cognitive neuroscience has made huge progresses in our understanding of a variety of human primary sensory functions such as taste, hearing, vision, and touch, as well as in our understanding of higher cognitive functions such as problem solving, memory, complex planning, executive functioning, and even consciousness (Gazzaniga, 2009). Currently, all recognized combinations of the neuroimaging literature control distinct foci rather than unremitting whole brain images.

Mostly neuroimaging literatures produce activated brain region's maps through some process of interest. When such maps draw inferences about the relationship between brain and behaviour, researchers often assume that these maps provide a comparatively accurate and comprehensive true effects picture. Unfortunately, in most cases, this assumption probably fails (Shallice, 2003). Therefore, a shift to image based data sharing will suggest major benefits to cognitive neuroscience research.

Conclusion

The next 20 years of cognitive neuroscience requires improving its methodological rigour, persistently using more vigorous approaches for statistical inference, focusing to a greater degree on recognising connectivity forms through the brain rather than concentrating on certain single region, and assembling other progresses to the way in which theoretical interpretations are drawn from neuroimaging figures.

The development of technology for measuring brain function and methods for analysing the huge databases thereby generated continue to drive advances in cognitive neuroscience research. Some future neuro-technologies like brain implants which involve cortical vision, hippocampal memory boosters, parietal cortex implants, and brain chips which involve cochlear implants and memory storage chips can give fruitful results in cognitive neuroscience.

It is obviously difficult to predict the future in the field of cognitive neuroscience, but with such a long and storied history from the ancient Greeks to new trends in recent years such as neuroimaging technology, it is difficult not to believe the future bodes well for the discipline.

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