Cognitive Psychology and Cognitive Neuroscience/Cognitive Psychology and the Brain

Introduction

Imagine the following situation: A young man, let’s call him Knut, is sitting at his desk reading some papers which he needs to complete a psychology assignment. In his right hand he holds a cup of coffee. With his left one he reaches for a bag of sweets without removing the focus of his eyes from the paper. Suddenly he stares up to the ceiling of his room and asks himself: “What is happening here?”

Probably everybody has made experiences like the one described above. But even though at first sight there is nothing particularly exciting happening in this everyday situation, a lot of what is going on here is highly interesting and relevant for researchers and students in the field of Cognitive Psychology. They are involved in the study of lots of incredibly fascinating processes which we are not aware of in this situation. Roughly speaking, an analysis of Knut's situation by Cognitive Psychologists would look like this:

Knut has a problem, he really needs to do his assignment. To solve this problem, he has to perform loads of cognition. The light reaching his eyes is transduced into electrical signals traveling through several stations to his visual cortex. Meanwhile, complex nets of neurons filter the information flow and compute contrast, colour, patterns, positions in space, motion of the objects in Knut's environment. Stains and lines on the screen become words; words get meaning, the meaning is put into context, analyzed on its relevance for Knut's problem and finally maybe stored in some part of his memory. At the same time an appetite for sweets is creeping from Knut's hypothalamus, a region in the brain responsible for controlling the needs of an organism. This appetite finally causes Knut to reach out for his sweets.

Now, let us take a look into the past to see how Cognitive Psychologists developed its terminology and methods to interpret ourselves on the basis of brain, behaviour and theory.

History of Cognitive Psychology

Early thoughts on the other hand, claimed that knowledge was stored in the brain.

Renaissance and Beyond

Renaissance philosophers of the 17th century generally agreed with Nativists and even tried to show the structure and functions of the brain graphically. But also empiricist philosophers had very important ideas. According to David Hume, the internal representations of knowledge are formed obeying particular rules. These creations and transformations take effort and time. Actually, this is the basis of much current research in Cognitive Psychology. In the 19th Century Wilhelm Wundt and Franciscus Cornelis Donders made the corresponding experiments measuring the reaction time required for a response, of which further interpretation gave rise to Cognitive Psychology 55 years later.

20th Century and the Cognitive Revolution

But before that, in the first half of the 20th Century, a radical turn in the investigation of cognition took place. Behaviourists like Burrhus Frederic Skinner claimed that such mental internal operations – such as attention, memory, thinking – are only hypothetical constructs that cannot be observed or proven. Therefore, Behaviorists asserted, mental constructs are not as important and relevant as the study and experimental analysis of behaviour (directly observable data) in response to some stimulus. According to Watson and Skinner, man could be objectively studied only in this way. The popularity of Behavioralist theory in the psychological world led investigation of
mental events and processes to be abandoned for about 50 years.

In the 1950s scientific interest returned again to attention, memory, images, language processing, thinking and consciousness. The "failure" of Behaviourism heralded a new period in the investigation of cognition, called Cognitive Revolution. This was characterized by a revival of already existing theories and the rise of new ideas such as various communication theories. These theories emerged mainly from the previously created information theory, giving rise to experiments in signal detection and attention in order to form a theoretical and practical understanding of communication.

Modern linguists suggested new theories on language and grammar structure, which were correlated with cognitive processes. Chomsky's Generative Grammar and Universal Grammar theory, proposed language hierarchy, and his critique of Skinner's "Verbal Behaviour" are all milestones in the history of Cognitive Science. Theories of memory and models of its organization gave rise to models of other cognitive processes. Computer science, especially artificial intelligence, re-examined basic theories of problem solving and the processing and storage of memory, language processing and acquisition.

Neuroinformatics, which is based on the natural structure of the human nervous system, tries to build neuronal structures by the idea of artificial neurons. In addition to that, Neuroinformatics is used as a field of evidence for psychological models, for example models for memory. The artificial neuron network "learns" words and behaves like "real" neurons in the brain. If the results of the artificial neuron network are quite similar to the results of real memory experiments, it would support the model. In this way psychological models can be "tested". Furthermore it would help to build artificial neuron networks, which posses similar skills like the human such as face recognition.

If more about the ways humans process information was understood, it would be much simpler to build artificial structures, which have the same or nearly the abilities. The area of cognitive development investigation tried to describe how children develop their cognitive abilities form infancy to adolescence. The theories of knowledge representation were first strongly concerned with sensory inputs. Current scientists claim to have evidence that our internal representation of reality is not a one-to-one reproduction of the physical world. It is rather stored in some abstract or neurochemical code. Tolman, Bartlett, Norman and Rumelhart made some experiments on cognitive mapping. Here, the inner knowledge seemed not only to be related to sensory input, but also to be modified by some kind of knowledge network modeled by past experience.

Newer methods, like Electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) have given researchers the possibility to measure brain activity and possibly correlate it to mental states and processes. All these new approaches in the study of human cognition and psychology have defined the field of Cognitive Psychology, a very fascinating field which tries to answer what is quite possibly the most interesting question posed since the dawn of reason. There is still a lot to discover and to answer and to ask again, but first we want to make you more familiar with the concept of Cognitive Psychology.

**What is Cognitive Psychology?**

The easiest answer to this question is: "Cognitive Psychology is the study of thinking and the processes underlying mental events." Of course this creates the new problem of what a mental event actually is. There are many possible answers for this:

Let us look at Knut again to give you some more examples and make the things clearer. He needs to focus on reading his paper. So all his attention is directed at the words and sentences which he perceives through his visual pathways.

Other stimuli and information that enter his cognitive apparatus - maybe some street noise or the fly crawling along a window - are not that relevant in this moment and are therefore attended much less. Many higher cognitive abilities are also subject to investigation. Knut's situation could be explained as a classical example of problem solving: He needs to get from his present state – an unfinished assignment – to a goal state - a completed assignment - and has certain operators to achieve that goal. Both Knut's short and long term memory are active. He needs his short term memory to integrate what he is reading with the information from earlier passages of the paper. His long term
memory helps him remember what he learned in the lectures he took and what he read in other books. And of course Knut’s ability to comprehend language enables him to make sense of the letters printed on the paper and to relate the sentences in a proper way.

This situation can be considered to reflect mental events like perception, comprehension and memory storage. Some scientists think that our emotions cannot be considered separate from cognition, so that hate, love, fear or joy are also sometimes looked at as part of our individual minds. Cognitive psychologists study questions like: How do we receive information about the outside world? How do we store it and process it? How do we solve problems? How is language represented? Here is a more detailed overview:

We hope you now have some idea what Cognitive Psychology is and what is involved in it.

Relations to Neuroscience

Cognitive Neuropsychology

Of course it would be very convenient if we could understand the nature of cognition without the nature of the brain itself. But unfortunately it is very difficult if not impossible to build and prove theories about our thinking in absence of neurobiological constraints. Neuroscience comprises the study of neuroanatomy, neurophysiology, brain functions and related psychological and computer based models. For years, investigations on a neuronal level were completely separated from those on a cognitive or psychological level. The thinking process is so vast and complex that there are too many conceivable solutions to the problem of how cognitive operation could be accomplished.

Neurobiological data provide physical evidence for a theoretical approach to the investigation of cognition. Therefore it narrows the research area and makes it much more exact. The correlation between brain pathology and behaviour supports scientists in their research. It has been known for a long time that different types of brain damage, traumas, lesions, and tumours affect behaviour and cause changes in some mental functions. The rise of new technologies allows us to see and investigate brain structures and processes never seen before. This provides us with a lot of information and material to build simulation models which help us to understand processes in our mind. As neuroscience is not always able to explain all the observations made in laboratories, neurobiologists turn towards Cognitive Psychology in order to find models of brain and behaviour on an interdisciplinary level – Cognitive Neuropsychology. This "inter-science" as a bridge connects and integrates the two most important domains and their methods of research of the human mind. Research at one level provides constraints, correlations and inspirations for research at another level.

Neuroanatomy Basics

The basic building blocks of the brain are a special sort of cells called neurons. There are approximately 100 billion neurons involved in information processing in the brain. When we look at the brain superficially, we can't see these neurons, but rather look at two halves called the hemispheres. The hemispheres themselves may differ in size and function, as we will see later in the book, but principally each of them can be subdivided into four parts called the lobes: the temporal, parietal, occipital and frontal lobe. This division of modern neuroscience is supported by the up-and down-bulging structure of the brain's surface. The bulges are called gyri (singular gyrus), the creases sulci (singular sulcus). They are also involved in information processing. The different tasks performed by different subdivisions of the brain as attention, memory and language cannot be viewed as separated from each other, nevertheless some parts play a key role in a specific task. For example the parietal lobe has been shown to be responsible for orientation in space and the relation you have to it, the occipital lobe is mainly responsible for visual perception and imagination etc. Summed up, brain anatomy poses some basic constraints to what is possible for us and a better understanding will help us to find better therapies for cognitive deficits as well as guide research for cognitive psychologists. It is one goal of our book to present the complex interactions between the different levels on which the brain that can be described, and their implications for Cognitive Neuropsychology.
Methods

Newer methods, like EEG and fMRI etc. allow researchers to correlate the behaviour of a participant in an experiment with the brain activity which is measured simultaneously. It is possible to record neurophysiological responses to certain stimuli or to find out which brain areas are involved in the execution of certain mental tasks. EEG measures the electric potentials along the skull through electrodes that are attached to a cap. While its spatial resolution is not very precise, the temporal resolution lies within the range of milliseconds. The use of fMRI (functional magnetic resonance imaging) benefits from the fact the increased brain activity goes along with increased blood flow in the active region. The haemoglobin in the blood has magnetic properties that are registered by the fMRI scanner. The spatial resolution of fMRI is very precise in comparison to EEG. On the other hand, the temporal resolution is in the range of just 1-2 seconds.

Conclusion

Remember the scenario described at the beginning of the chapter. Knut was asking himself “What is happening here?” It should have become clear that this question cannot be simply answered with one or two sentences. We have seen that the field of Cognitive Psychology comprises a lot of processes and phenomena of which every single one is subject to extensive research to understand how cognitive abilities are produced by our brain. In the following chapters of this WikiBook you will see how the different areas of research in Cognitive Psychology are trying to solve the initial question raised by Knut.
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