COGNITIVE PSYCHOLOGY

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Contents

Summary

This article presents an overview of cognitive psychology and how cognitive psychologists investigate human cognition. In particular, it summarizes what we know of different cognitive activities, such as memory, high-level cognitive activities (reasoning, decision making, and problem solving), and language. The main determinants of people's performance in these activities are briefly presented and discussed. Finally, future directions considering what we shall learn from imaging techniques are proposed.

1. Introduction

Cognitive psychologists want to understand (human and animal) cognition. Cognition, a modern term for "intelligence," is the life function accomplished by the cognitive system (i.e. the mind) and is involved in many everyday and formal activities. Such activities include remembering a telephone number for a short while, recognizing a friend in a crowd, learning a new set of knowledge at school, making personal and social decisions, understanding the implications of what people say to us, solving formal (e.g. mathematical) and informal (e.g. personal) problems, speaking and writing language material, and understanding what other people say.

Put more formally, cognition involves a wide variety of domains, such as perception, pattern recognition, memory, reasoning, decision making, problem solving, and language processing. Within as well as above and beyond each cognitive domain, research aims at understanding precisely (a) by what mental processes and representations people accomplish cognitive tasks and (b) what are the general constraints (e.g. memory limitations) on cognitive functioning.

To understand cognitive processes and mental representations involved in cognition, psychologists collect data (via experiments or other forms of observations) and build theoretical models. Experiments enable psychologists to determine what factors affect people's cognitive performance, as measured by the time taken to accomplish a task or how accurate people are when they solve problems or try to store information in memory.

To illustrate, suppose psychologists want to determine the processes involved in solving simple arithmetic problems. They can run an experiment in which they ask participants to solve a series of addition problems (e.g. 8 + 7 = ?). Solution latencies and percent errors as a function of the type of problems will be good indicators of how participants solve these problems. For example, suppose the issue is to determine whether people count from the larger addend or retrieve the solution directly from memory. The hypothesis that people use counting predicts that solution latencies should vary across problems as a function of the smaller operand (i.e. in 8 + 4, 4 is the smaller operand), so that people should solve 8 + 4 faster than 8 + 5, which they should solve faster than 8 + 6. The linear relationship between size of the smaller operand and solution latencies is thus to be examined. If the best predictor of solution latencies is the smaller addend, it is reasonable to assume that people count.

However, suppose the best predictor of solution latencies is the size of the correct sum. This would falsify the counting model and make the retrieval model (i.e. people access the solution directly in long-term memory) more plausible. Relationships between different kinds of variables (like problem or participant characteristics) and different behavioral indices (like latencies or percent errors) are often fruitfully used in cognitive psychology to understand how people accomplish cognitive tasks. This will be illustrated in this article when considering memory, high-level cognitive activities, and language processing. For each of these, we first provide generic definitions and then an overview of what determines people's cognitive performance.

2. Memory

Memory is fundamental for our survival. With no memory, it is impossible to know who we are and who the people around us are, where food is, how to get back home, and so on. Psychologists have always wondered what the fundamental characteristics (i.e. capacities and mechanisms) of memory are. To find out, they run experiments and build theoretical models to understand how human memory works, that is how we store (and retrieve) information in (and from) memory, how information is represented and organized in memory, how many memory systems there are, and what are the causes of forgetting.

Psychologists have discovered that human memory involves a set of different types of memory, what the facilitative factors of memory performance are, and how information is organized in (and retrieved from) long-term memory. We first present the distinction made by psychologists among several types of memory and then the main determinants of memory performance.

2.1. Several Types of Memory

2.1.1. Working Memory

There are two memory systems: working memory and long-term memory. Working memory refers to the temporary storage and processing of information in a variety of cognitive tasks. Working-memory capacity is limited (i.e. people can store 7 ± 2 elements for about 15 seconds if they do not mentally rehearse the material). That is, if I show you 25 words with one word every second, you are going to memorize 7 ± 2 words; if I show you 25 pictures, you are going to remember 7 ± 2 of them; and if I show you 25 digits, you may recall 7 ± 2 of them. This memory capacity can be circumvented to some extent if we use strategies like mental rehearsal or chunking. Chunking consists of grouping material, such as when words are grouped into sentences or digits into three-digit numbers. This working-memory limit constrains people's performance in a wide variety of cognitive tasks.

Working memory is subdivided into (at least) three components: The central executive monitors the allocation of attentional resources during cognitive activities, the phonological-articulatory loop stores and manipulates speech-based material (such as when we have a conversation with friends), and the visuo-spatial sketchpad is responsible for storage and manipulation of visuo-spatial material (such as when we try to find our way to visit friends).

2.1.2. Long-Term Memory

Long-term memory (LTM) refers to the (almost permanent) storage of information and retrieval of information. It has also been subdivided into subsystems. Classically, psychologists distinguish between semantic memory (in which general knowledge is stored) and episodic memory (in which episodes or personal events are stored). Another distinction is between explicit (in which material is consciously stored and retrieved) and implicit memories (for which conscious awareness is not necessary during storage or retrieval). Whether working- and long-term memories are fractionated or involve different kinds of processes in different kinds of tasks is still a matter of debate in the memory domain.

To investigate different types of LTM, psychologists have devised several kinds of tasks. A typical experiment in explicit and implicit memory research involves two phases, one storage phase (which is the same for both explicit and implicit memory) and one recall phase (which is different for both types of memory). During the storage phase, psychologists ask participants to learn some material (e.g. lists of words, sentences, pictures, objects). To learn this material, individuals do either whatever they want (e.g. they can mentally rehearse material or do mental images) or what the experimenter asks them to do (e.g. participants are required to make mental images with each word of the to-be-remembered list). In the second phase of an explicit memory task, participants are explicitly asked to recall the material.

To do this recall, participants are asked to say all the words they remember either in whatever order they want (i.e. free recall) or in the same order they studied (serial recall). Recall can be cued recall (i.e. people are given a cue such as the name of the category of the to-be-recalled word) or not (i.e. people are just asked to recall what they just learned). People's performance is investigated as a function of a number of factors, such as list length, word frequency, or whether people were asked to do some special mental activity (e.g. to make mental images while storing material).

Thousands of memory experiments have shown that memory performance is improved when people learn concrete material (as compared with abstract material), process information as deeply as possible (e.g. doing mental images with to-be-remembered material), create mental associations between newly-processed information and previously (familiar) stored information, or are very motivated or under high pressures to learn new material.

2.2. Main Determinants of Memory Performance

2.2.1. Effects of Material Characteristics

Some information is easier to store in memory than other information. For example, when people's memory is tested through asking them to store a list of words to remember, words that refer to concrete objects (e.g. table) are easier to remember than words that refer to abstract entities (e.g. justice) either because these words are more common or because people can more easily make mental images with them.

Material organization is another example of material characteristics that affect memory performance. Suppose participants in a memory experiment are asked to memorize the following list of words: "apple, carrot, leeks, peach, pear, banana, green beans, potato, cranberries, orange, broccoli, cabbage," or to memorize the same list but in the following order: "apple, carrot, peach, pear, banana, cranberries, orange, leeks, green beans, potato, broccoli, cabbage." It will be easier to remember the second list than the first, because it is categorically organized (all fruits are stored and recalled together and all vegetables are grouped together).

2.2.2. Effects of Memory Strategies

Memory strategies refer to how people try to encode, store, and retrieve information in memory. Examples of such strategies include mentally rehearsing the material, processing the material as deeply as possible (i.e. building mental images and establishing mental links between new and old material, hierarchically reorganizing the material), finding good cues. Some strategies are much more efficient than others. For example, in a 1974 experiment Eysenck gave four groups of people the same lists of 24 words each to learn. The first group was asked to count the number of letters in each word (e.g. the word “table” has 5 letters). The second group was asked to provide a word with the same rime as the to-be-learned word (e.g. “plate” and “slate” have the same rime). In the third group, participants were asked to provide a characteristic for each word (e.g. “sweet” for “warm”). Finally, the fourth group had to build a mental image of each word of the list. People had better performance in the third and fourth groups than in the first two groups, because they processed information more deeply (i.e. they had to process the meaning of each word).

2.2.3. Effects of Information Organization

How information is organized in memory has proved as crucial in memory performance as mental activities during both storage and encoding of information. In memory, information is associatively organized. Associative networks include nodes representing concepts and links between nodes for interrelated concepts (see illustrative example in Figure 1). Links are of different strengths and retrieval of a concept operates through the activation of one node. Activation spreads through the associative network. Changes in node strengths characterize part of the learning process.

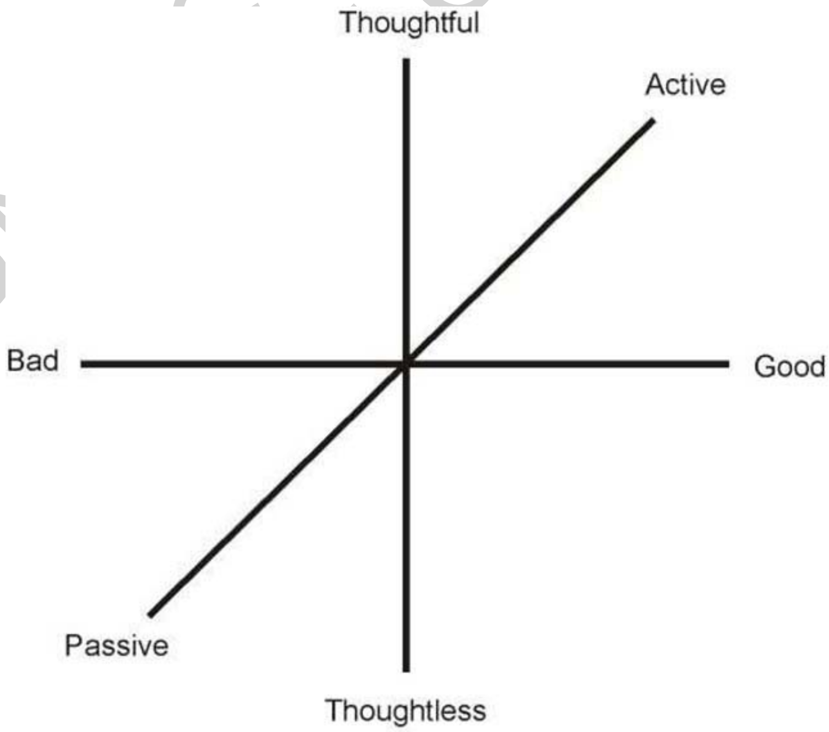

Figure 1. Example of associative networks

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Bibliography

Anderson J.R. and Lebiere C. (1998). *The Atomic Components of Thought*, 490 pp. Mahwah, N.J.: Lawrence Erlbaum. [This book is a collection of theoretical papers showing the kind of theory cognitive psychologists are able to build to account for human cognitive performance in a wide variety of cognitive activities.]

Best J. (1999). *Cognitive Psychology*, 5th edn., 524 pp. New York: West. [This is a good textbook in cognitive psychology, presenting in great detail what we know about human cognition.]

Harley T.A. (2001). *The Psychology of Language. From Data to Theory*, 2nd edn., 528 pp. Hove, U.K.: Psychology. [This book provides a good overview of what we know regarding language processing.]

Lemaire P. (1999). *Psychologie Cognitive*. Bruxelles: De Boeck Université. [in French.] [A cognitive psychology textbook.]

Newell A. (1990). *Unified Theories of Cognition* (The William James Lectures; 1987), 549 pp. Cambridge, Mass.: Harvard University Press. [Present a theoretically-oriented overview of human cognition and detailed models of cognitive activities.]

Biographical Sketch

Patrick Lemaire started his career as a researcher at the Laboratoire de psychologie cognitive (CNRS) in Marseille, France, after completing postdoctoral studies at Carnegie Mellon University with R.S. Siegler. He continues to conduct research in this laboratory and is also professor of psychology at the Université de Provence in Marseille, France. Besides his duties as a professor and researcher, he is also an active member in various professional and scientific societies: Psychonomic Society, Society for Research in Child Development, American Psychological Association, American Psychological Society, European Society for Cognitive Psychology, and the Société Française de Psychologie. Professor Lemaire is author of two books and some 30 articles on cognition, numeric cognition, and cognitive development and aging.