Introduction to Cognitive Psychology

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Wilhelm Wundt (1832-1920)

The study of cognitive psychology dates back to the early days of psychology. In 1879 Wilhelm Wundt founded the first lab for psychology in Leipzig Germany. One of the first things to be studied by early psychologists was such phenomena as: sensation, perception, and attention. In this book we will study such things and even more advanced topics as well. The early founders of psychology were interested in looking at how the mind perceived things and asked how the mind acquires information? Even before the invention of the computer we can see where early psychologists were looking at the same things that modern cognitive psychologist look at. Today cognitive psychologists use the computer model to compare the mind to a computer. How does the brain acquire information or data and how does it process that? In defining **cognitive psychology** some important characteristics of cognitive psychology are:

1. It is an interdisciplinary study of the mind. Cognitive psychology is a subset of **cognitive neuroscience**. Cognitive psychologists collaborate with many other different types of scientists in a branch division of cognitive neuroscience called cognitive science. When you think of cognitive science, cognitive psychology is only one branch. There are contributions from other fields such as computer science, biology and even philosophy and engineering.
2. Cognitive psychologists use the scientific method as well as other methodologies. Particularly we find the use of computer modeling and artificial intelligence as alternate types of modeling.
3. Cognitive Psychology encompasses multiple diverse disciplines. Often you will find that a cognitive psychologist can be something of a polymath. Many cognitive psychologists are also expert programmers and have a diverse background.

By the end of this book many students will be able not to just read journal articles in cognition, but may be able to read journal articles in computer science journals. This is because in order to truly study cognition one needs to be multitalented in different ways of data processing. Finally cooperation and communication between disciplines is important. Many journals in cognitive psychology are interdisciplinary, however this might involve collaborating with biologists and computer scientists as well. In this book we will take an approach on showing the applications of cognitive psychology in fields outside of cognitive science. For example nursing as well as mental health will be discussed in topics such PTSD, ADHD, and aging.

1.1 Cognition Defined

Cognition is defined as the mental events and knowledge we use when we: recognize an object, remember a name, have an idea, understand a sentence, or solve a problem. If we really want to describe cognition in its most basic form, it is the brain's processing of information. In cognitive psychology we use the computer model. In the computer model such things as personality or social interaction are more described as applications. In computer examples of such applications are social media or video games. In cognitive psychology we are actually looking at how the individual parts of the brain, the hardware if you will, are able to process the information. In this situation cognition is more or less analogous to the operating system of the brain. How does the hardware process information and manage all the applications? One way, in which we can do this, is again the use of the computer model. However modeling is only part of what we do. Cognitive psychology also has empirical models.

1.2 Four Assumptions of Cognitive Psychology

Certain assumptions about mental processes are required for how the brain processes information. The first assumption is that mental processes exist. The second assumption is that mental processes can be empirically studied. Cognitive psychologists use an array of measures to study mental processes. The third assumption is that humans are active information processors. Any stimulus that a person comes in contact with is processed to some degree. Finally some mental processes can occur with only minimal conscious

awareness. Many mental processes are actually automated. This allows for the conscious processing of the more difficult tasks people face on a day-to-day basis. For example, when one person might be utilizing a phone either to talk or to text, while walking down a hallway, how much conscious effort do you put into walking? Do you think, "I must place my left foot over here and put my right foot over here?" In fact you have automated the process of walking. In fact what we find here is that this is actually a dual-task process where you are walking and texting at the same time. In this case most of the conscious processing is focused on texting, while walking is largely automated and unconscious. The problem that you will encounter is that during automaticity in a dual-task one of the tasks will suffer. Believe it or not your walking is actually at a worse performance than if you were to walk without using your cell phone.

Table 1 The Four Assumptions of Cognitive Psychology

1.	Mental processes exist.
2.	Mental processes can be studied empirically.
3.	Human are active information processors.
4.	Some processes happen automatically and without conscious control.

The other assumption about mental processes is that mental processes are complex. The concept of studying such complex mental processes requires different protocols. These different protocols are approaches that seek to clarify the mental processes while at the same time reducing the influence of extraneous variable. One such protocol is the reductionist approach. The reductionist approach involves breaking down the mental processes into small stage-like models and interacting with minute detail. As a result many studies in cognitive psychology will consist of a series of experiments that manipulate different stages or different levels of the independent variable to try and isolate their functions by using the reductionist approach.

Another common issue that must be clarified when studying cognitive psychology is, "What is memory?" And in what ways is memory similar to and different from cognition? In examining these similarities and differences to is construed that memory is a process, but also memory can be construed as a place or a type of storage. When looking at memory, memory deals with both conscious and automatic recalling. In this aspect of memory we find that there are redundancies in memory. We might store things in different codes; different ways of which that information is accessed reflects the processes of memory. These processes of memory can encompass different actions that can be performed at the time of encoding such as applying mnemonic strategies that will aid in retrieval such as visualization or rhyming. How this is accomplished when we look at the relationship between cognition and memory is the idea of representation. Much like in a computer, in the hardware we will have circuits or magnetic fields that are the basis for binary computer language. In binary on or off in a certain order will indicate a certain character on the computer. So what we find, in certain ways, is that representations will have a similar characteristic between circuits and neural activation patterns.

Two ways of which people can identify memory representations are format and content. The format is referring to the specific modality. Modality refers to the sensory organ coding such as vision, audition, etc… In this manner we can store information based on visual code, such as what does a giraffe look like? Or we can base it on sound; such as not what does a hippopotamus look like, but what does the word hippopotamus sound like. The second way of identification of representation is by content. The use of content gets into semantic meanings such as what is the definition of something. Content becomes apparent, particularly, when looking at certain abstract concepts. People might have an easy time giving you a definition of what is freedom, but not be able to visualize it. Content also relates to how humans store information. Do we store things by adjacent content such as things of a similar meaning? In this example we might find that we might store our knowledge of ships by things associated with other ships such as sailors, shipwrecks, pirates, and other such things.

Again the reductionist approach is an attempt to understand complex mental processes by breaking them down into smaller, discrete components. A meta-theoretical assumption for the reductionist approach is that cognition is broken down into three basic processes. The first process is encoding. Using the computer analogy, encoding is an input function such as bringing in data by means of being typed into the computer via key strokes on the keyboard when we are using a word processing program. Retention is the second process. Retention is a matter of storage such as saving that information. Finally there is retrieval/execution, which would be the output function such as pulling up the file or having the computer, play back a recording to you.

Neisser (1976) discussed **ecological validity**. Ecological validity is the everyday application of scientific discoveries. This could also be described as the practical value of scientific research. In cognitive psychology much of the research that is done occurs in a pure research setting. This means that it does not look for applied everyday value in the experimental results. This is because the reductionist approach often precludes the extension into applied settings. However, what we do find, and you will see in this book, that much of the large body of pure basic research can be aggregated and put into other studies, which will have tremendous ecological validity and impact in everyday life. For example many of the breakthroughs in posttraumatic stress disorder result from the field of cognitive psychology, which focuses on learning, memory, and how people process information.

In order to study cognition one must follow certain assumptions of cognitive psychology. There are four basic assumptions. The first assumption is that mental processes exist. The second is that mental processes can be studied scientifically. If it exists it can be studied. Early in the days of psychology Wilhelm Wundt and Edward Itchier utilized incorrect methods of studying mental processes. They tried introspection. **Introspection** is thinking about thinking. In this method the experimenter is also the subject ($n = 1$). In this method the experimenter/subject observes a stimulus and records their conscious mental processes. Modern cognitive psychology applies more empirical processing based upon results. Many cognitive psychologists might use a computer-based testing approach where some piece of information is manipulated. The third assumption is that humans are active information processors. Miller called us informavores. We find that any piece of information is processed. Some bits of information are processed with greater detail than others and this ties into the fourth assumption. The fourth assumption is that some processes occur without conscious awareness. Many of our processes are automated, that includes going back to being an active information processor that some information is processed without our awareness. This phenomenon occurs in priming paradigms where people might see a stimulus, process it, but not consciously process it due to the brief exposure to the priming stimulus, but the priming does affect their performance later on.

1.3 Early Psychology

Some of the first psychologists as we mentioned before studied under Wilhelm Wundt and their work could be described to fall within the realm of modern cognitive psychology. Although the modern understanding of psychology, particularly by those who have not taken a course in psychology, assume that most of psychology is about counseling or social psychology. In fact much of psychology is an experimental approach to behavior and almost all of early psychology was cognitive in nature. The early psychologists studied sensation, perception, and attention. Things like social psychology and counseling was incorporated later on. Early on the study of personality or social interaction was actually rejected by the early psychologists who wanted to model the field of psychology on other hard sciences such as physics and chemistry.



Wilhelm Wundt is hailed as the founder of psychology. In his laboratory he advocated for empirical methods.

Originally early psychology studied sensation, perception, and attention before the advent of computers. How could they study such complex and fast mental events when they lacked the modern tools used in cognitive psychology today? The method they used, which was criticized later, was introspection. The assumption the early psychologists used was that if one is going to study thinking, one must actually study their own thoughts since you cannot see the thoughts of others. Therefore the method of introspection is where one looks carefully inward reporting inner sensations. Criticism of this is that this reduces the sample to an *n* size of one. Almost all of the early psychologists used themselves as test subjects. You can see where this can relate to bias as well a non-representative sampling. Now modern cognitive psychologists use large sample sizes and do not place themselves as test subjects.

Examining Wundt's contribution and the contribution of his followers to cognitive psychology, we are shown that mental activity can be broken down into basic processes. Also they developed more objective methods for studying mental activities. A good example would be if you were to look at the Archives of American psychology in Akron, Ohio at the University of Akron. The archives have, from around the time of Wundt, shotgun shells. What these were used for is to study the discrimination of weight differences. The shotgun shells were all the same size so one could not visual discriminate between the weights. However, they would be filled with different weights such as sand or gravel and would weigh a few grams

more or less than other shotgun shells. What subjects would do is hold each of the shotgun shells in their hand and guess how much the weight was and if they could discriminate between a few grams. This was an objective measure. Here we had an objective weight by having the same size but different weight.

1.4 Prominent Early Cognition Researchers

Edward Titchner was not interested in memory. Edward Titchner wanted to purify psychology and its understanding of processing of mental resources. One assumption he had was that which in impure is not to be studied. Certain aspects of psychology involve too many extraneous factors which cannot be held constant. For example social interactions, social psychology, mental illness, counseling were deemed as not related to pure mental functioning. This is because for social interaction factors such as transient mood and the like cannot be controlled. Titchner did utilize the introspection method. One of the concepts that were put forward by Itchier is structuralism. Structuralism suggests that the structure of the mind, as well as sensation, images, and feeling are the elements of the mind structure. For Titchner how the mind is organized rather than how it functions is of paramount importance. This school of thought was advocated by Edward Titchner who was its sole authority. Not long after the death of Edward Titchner structuralism fell by the wayside.



Hermann Ebbinghaus (1850-1909)

One of the researchers in the early days of psychology whose contributions are still seen today inside many journals of cognitive psychology is Hermann von Ebbinghaus. Hermann von Ebbinghaus did most of his work while in a bookstore. His research was focused on memory. He thought that objective methodologies were possible for studying the mind. His preferred method was the use of nonsense syllables, such as CVC or ADL. Nonsense syllables were favored because these were not actual words and therefore would be referred to as a natural/sterile stimulus unlike if you were to use words. Words could be tainted with emotion and familiarity. His method was to study a list of nonsense syllables and count the number of trials it would take to accurately reproduce all the nonsense syllables. He would then wait an appropriate amount of time that he would deem and then try to repeat the list. Ebbinghaus would study the list again until he could accurately recall all the nonsense syllables and then he would count how many times it would take him to relearn or practice the list over again until he got it right. For example if he had a list of 20 nonsense

syllables and it took him 10 trials to get to 100% accuracy and then after a period of two hours he would have to rehearse it twice before he got back to 100% accuracy. This would be a **savings score** of eight trials. His first book on memory was published in 1885 and much of his research is still widely used and cited today.

One of the most influential psychologists in the early days of psychology in America was William James. William James had a diverse interest in psychology. Much of his work was more theoretical and borderline philosophical. Some of his ideas were revolutionary and others have been dismissed as incorrect. This was because William James's research methods were not as stringent as other researchers such as Ebbinghaus. One notable area of research that William James provided for the study of cognition is the division of memory. He divided memory into two basic areas. One area of memory is of immediate circumstance and the other one is larger, more hidden, or passive. The memory of immediate circumstances was referred to as primary memory and the larger and passive or hidden memory was referred to as memory proper. What William James was referring to here is where the spotlight of attention and consciousness would be for memory and in essence he was dividing it between short-term and long-term memory. Short-term memory is where someone might rehearse material that is not yet committed to long-term memory. It is also to where attention is focused. As a result conscious attention is also there. Long-term memory is more of a large storehouse. Many things that we know are not in consciousness at this time. They are not being paid attention to and therefore are still in memory, but not in our current focus of attention.

1.5 Behaviorism

In 1913 John Watson started a movement within psychology known as behaviorism. The focus of behaviorism was to look at observable and quantifiable behavior. This was viewed as the proper topics for psychology. Behaviorism was referred to as the objective study of the mind. As a result very little research in cognition was preformed particularly because methodologies at that time did not allow for easy empirical measurement of cognitive functions.

In modern cognitive psychology computers are utilized to assess things such as reaction time measured in milliseconds. In the early 20th century such things were impossible at that time. Therefore accurate, reductionistic evaluation of cognition was nearly impossible. Watson wanted to make sure that psychology used purely scientific methods. It is interesting to note that Watson was unaware of the work of Ebbinghaus. If Watson had been aware of the work of Ebbinghaus perhaps behaviorism and psychology in general would have been altered radically.

One of the reasons that behaviorism came about was because of physics envy. Physics envy was a phenomenon in early psychology in which it was desired that psychology be modeled after hard and established sciences. At that time physics was the premiere science worldwide. We look at the year following the founding of behaviorism, 1914, during the outbreak of World War I, Albert Einstein and his theory of relativity was actually on the front page of newspapers superseding reporting on the First World War. Therefore, people were very interested in physics and exact sciences. Psychology at that time wanted to emulate physics. As a result, because behaviorists would only measure observable outcomes very little research was done in cognition. What was found during the early 20th century to the middle of the 20th century was work on verbal learning, which was referred to as quasi-cognitive research. It was still regarded as a second-class field of research. Much that was going on was learning trials particularly with animal models. To this end Watson and his followers wanted to purge all mental processing that was unable to be verified by an independent observer.

1.6 The Cognitive Revolution

In the 1950s we see what will be the start of what will be referred to as the cognitive revolution. The cognitive revolution was not an overnight radical revolution as one might think. It was a gradual process that came about as a scientific debate. Within psychology most people were starting to have disagreements about the goals and efficacy of behaviorism (see the section on psychology in World War I). One of the disagreements that came about was that when looking at the behaviorist paradigm all new behaviors came through conditioning. It was stimulus-response models for all phenomena within psychology. That paradigm did not allow for complex or innovative thought and behavior. As mentioned before although we do use a reductionist approach in cognitive psychology we are able to use multiple stages and multiple studies to show an overall elaborate complex behavior. This is not behaviorism. Behaviorism focused on simple behaviors and the relationship between stimuli. It did not account for already existing cognitive processes which might influence behavior. For the behaviorist the environment was the catalyst for all behavior.

Another criticism of behaviorism was that animals were used almost exclusively for behaviorist experiments. There were several problems with this approach. One was instinctive drift. Animals would be taught to perform certain tricks. For example raccoons were taught to put money into a piggy bank as a novelty act. However, what would happen is that periodically a raccoon would not put the money in the piggy bank, but would actually start to wash it in the water dish. Washing is an instinctive behavior of raccoons, particularly to wash their food. Another and more interesting factor is that when comparing animal and human cognition the two are radically different. Both have instincts. If we look at human beings, humans have special tool using instincts that are advanced beyond other animals. Also language is a big factor in separating human cognition form nonhuman cognition. In humans language is used as a code for memory which is not analogous in any animal that we know of at this time. Another point of dispute was a big theoretical disagreement over the use of theories as the basis for experimentation. In particular, BF Skinner thought that basic guiding assumptions rather than specific theories were necessary for the purpose of experimentation. However within the emerging world of cognitive psychology was the use of theories. The psychologists were trying to make these theories testable and replicable. These theories were more process specific rather than large guidelines about behavior.



B.F. Skinner (1904-1990)



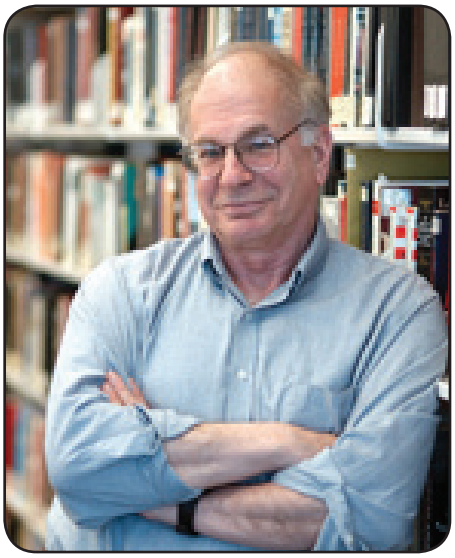
Noam Chomsky (1928-)

The defining moment where one can say that the cognitive revolution was starting to take off and pick up momentum is in 1959. In 1959 Noam Chomsky countered BF Skinner's assertions of the acquisition of language, in Skinner's 1957 book *Verbal Behavior.* In the book Skinner argued that language is acquired through reinforcement and therefore if one were to say something to their child, their child would then acquire it. In Chomsky's rebuttal he pointed out that language is generative and discussed the notion of the language instinct. This is a human instinctive behavior, something that would not be studied or could be studied by behaviorist. Chomsky argued that language being generative is demonstrated in that children have an instinct to acquire language and will start to understand the rules of a language rather than being reinforced and imitating exact language. An example of this is if a child learns to call a foot "a foot", and then parent address the child saying "let's put your shoes on your feet", and the child will correct the parents by saying, "foots". But this is not a term parents would use therefore the child created this word. It was generated by using the rules of language. The child knew to add an "S" sound to the end of the word makes it plural. Therefore when children are acquiring language they will use this rule to understand the plural of *foot* is *foots* which is not the case for English.

Other things that advanced the cognitive revolution were that computers were starting to become more regularly used in laboratories. This led to the computer model of cognition as we studied earlier. This model is important. Around the time of the 1950s computers started coming into use in a few isolated labs, particularly government and academic labs. However greater interest was coming aboard. Yet another factor that came about was prestige. In 1978 Simon won the Nobel Prize in economics for his work in applying cognitive principles and theories to economics. Later in 2002 Daniel Kahneman also won the Nobel Prize again in economics for applying cognition to human behavior and economics.



Herbert Simon (1916-2001)



Daniel Kahneman (1934-)

1.7 Modern Cognitive Psychology

Cognitive psychology is made of guiding principles. In addition to the four main assumptions there are some meta-theoretical assumptions. Meta theoretical assumptions are sets of assumptions and guiding principles that are used in every theory in every study in cognitive psychology. The most important one is

the big paradigm is the information-processing approach. The information-processing approach states that we process information in a coordinated operation of active mental processes within a multi component memory system. This implies that we will undergo a series of stages, which will process different bits of information in different areas. One of the most recent changes in terms of understanding the information-processing approaches is that prior to a few years ago it was assumed in the information-processing approach that one processing stage must finish before another stage can begin. There is currently more evidence of parallel processing starting to emerge. The idea that is emerging is where multiple mental processes can be occurring all at once.

Within cognitive psychology there are seven themes, which are topics of interest for researchers.

1. Attention
2. Automatic versus conscious processing
3. Data-driven versus conceptually driven processing
4. Representation
5. Implicit versus explicit memory
6. Metacognition
7. The brain

Attention. Attention is an input function for acquiring information. Researchers are curious about the ability to utilize attention to multiple tasks/stimuli. Can we pay attention to more than one thing at a time? What things grab our attention or guide it? In what ways can attention be improved?

Automatic versus conscious processing. Thinking back to William James's definition between primary memory and memory proper. We look at what information is being processed without effort versus the more effortful conscious processing. Researchers find that people are able to do some things automatically involving very little thought. Other things require great mental effort. Particularly when we look at the idea of dividing attention among different tasks, this division of attention that involves automatic versus conscious processing is in the hot topic in psychology of driving and texting. We find that one process that is relatively automatic becomes impaired and the conscious effort actually detracts from important activities such as visual scanning to prevent accidents.

Data-driven versus conceptually driven processing. This is also referred to as **bottom-up processing** versus top-down processing. These refer to whether our attention and mental actions are guided by the stimulus itself such as in data-driven or in a conceptually driven process where the mind itself guides the scope of attention on a task. If we look at problem solving where we do not have any assumptions or prior understanding of the problem we will take whatever data comes along our way. For example if someone were to read a detective novel and did not know who is the culprit in that book, each clue or bit of data that comes along to the reader will serves as a data-driven process where the reader is acquiring information to guide the reader into making an assumption about the identity of the culprit.. However if the reader were to look at the end of the book first and find out who the culprit is that committed the crime, then reads the book the reader knows who the villain is. The reader will pay attention only to the culprit's actions and disregard other characters who may have served as red herrings in the storyline.

Representation. Representation refers to how memory is stored. There are many codes in the human brain used for storing information. There are visual, auditory, and semantic to name a few. Relevant to the study of cognition is how experimenters can find different ways of which information is stored. For example, the mnemonic theory of olfaction, also known as the Proustian view of olfaction, states that the sense of smell is stored as episodic memories. In this example, if you remember something such as the smell of cookies you might note that it smells like your grandma's cookie and you will attach to it a particular memory. This is in contrast to referring to a specific quality such as this smells two parts sweet, one part bitter or something of that nature when identifying the smell of cookies.

Implicit versus explicit memory. Implicit and explicit memories are similar to automatic versus conscious processing, but refer to more than just attention. It also refers to retrieval of information. For example when studying for a test you are using an explicit memory that is very conscious. A little mnemonic to help you remember is that the E in explicit stands for effort. This is a mnemonic which is a mental shortcut for remembering. Utilizing a mnemonic is a type of explicit memory where you are consciously and effortfully trying to encode something and remember it. Implicit memory on the other hand is where something is learned or acquired automatically with no intention at all. For example, catchy songs have the tendency for implicit processing. Many people do not intend to acquire the lyrics of certain songs, but the acquisition and retrieval are outside of explicit processing.

Metacognition. Metacognition is an important topic when looking at expertise and complex mental actions. Metacognition is the understanding of one's own mental strengths and weaknesses. It has importance with learning as well as aging. It has been found that people with better cognitive function and higher intellect are more aware of their own metacognitive abilities. Everyday examples of metacognition are when people describe themselves as saying, "I am great with names and terrible with faces" or they might point out that they are better at remembering things such as words, but not numbers. Reflecting back on the topic of implicit versus explicit memory, one can see the importance of metacognition when people with high metacognitive skills might use mnemonics to help them remember things more easily.

Brain. The brain is a topic of interest for researchers in cognition. The use of the brain in theories and models attempts to define how does the structure of the brain and function mimic cognitive behavior? We will see where this relates to theories of vision. For example some theories of visual object recognition were proven to be incorrect due to the fact that the types of processing described by the theories were neurologically implausible. This is a common theme in psychology. It is postulated that any good theory in cognition must be neurologically plausible therefore a good understanding of the brain physically helps researchers understand the brain cognitively.

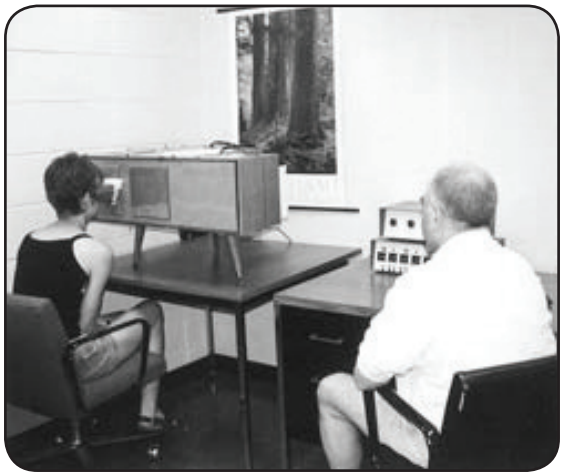
1.8 Methods of Experimentation

If cognitive processes are unseen but observable how do you measure it? In cognitive psychology there are four basic methods of measuring outcomes (dependent variables).

1. Reaction time
2. Accuracy
3. Verbal reports
4. Neurological evidence

Reaction time is a measure of the time elapsed between some stimulus and the person's response to the stimulus. For example if a person sees a red circle and takes 600ms to respond, the reaction time is 600ms. One issue with this is how are we able to identify not just the overall performance, but perhaps measuring one of the stages in the overall cognitive process. This involves the reductionistic approach. In 1868 Donders came up with the speed of mental processing, referred to as Donders' method of subtraction. If we are to look at a certain task, we can measure overall behavior. What we can do is look at the stages that are involved in this particular task and then remove one. For example if we have a cognitive process that consists of stages A, B, and C and it takes the subject an average of 1200ms to complete this process altogether, we may have trouble isolating A, C, or B, but we may be able to remove stage B. What we find here is that just completing stages A and C together takes 800ms. Therefore we can conclude that it takes an average of 400ms to complete stage B.

A running example of this would be if we have a task where people must identify whether something is in the shape of a triangle or a square, and then respond to the color of it. For example if the item is red hit one button, if it is blue hit another button. However you must first judge whether it is a triangle or a square first. If and only if it is a triangle you respond that it is red or blue. In this case we have an input stage and output stage. We also have two central stages, one where a decision must be made upon a shape and another on color. Let us say the average reaction time is 1600ms. What can be done then is that if we want to understand: how long does it take a subject to determine shape? We can then remove that shape task and have people perform a task where they do not have to make a decision. They will see the stimulus and not have to decide whether it is a triangle or a square. In this situation they don't have to make a decision based upon shape all. They have to make a decision based upon color only. What we find in this case is that the average reaction time is 1300ms. Prior, when they had to make the decision on the shape before the color it took 1600ms, now without that decision it is 1300ms. One can then conclude that 300ms is sufficient for processing the stage of shape discrimination.



The tachistoscope is a device used to present a stimulus to subjects for a predetermined about of time. Tachistoscopes were used before computers became prevalent.

The second most important dependent variable is accuracy. Accuracy was the dependent variable of the work of Hermann von Ebbinghaus. Ebbinghaus used accuracy instead of reaction time. In modern cognitive psychology both accuracy and reaction time are the two most important ones that are used time and again. Interestingly enough, both correct and incorrect accuracy are important dependent variables. It can be observed that manipulations of certain stimuli lead to certain types of incorrect answers. These errors give us an indication of what factors may be involved in a process. Another factor is to look at how people remember information. This would be gist versus exact memory. Many times when you do not actually remember what was written word for word you conceptualize it into the basic gist. This is a more parsimonious form of memory and one that is more commonly used.

Verbal reports are used when looking at large complex behaviors, particularly decision making behaviors. In these situations what happens is that the reaction time would be measured in seconds if not minutes and would therefore be more problematic. Therefore the subject is instructed to verbalize their thoughts as they solve a particular problem.

Neuropsychological evidence is a way of measuring outcomes. Particularly we find this works in clinical settings. This is used frequently in case studies where a patient might have damage to a certain area of the brain and a particular behavior is absent. Researchers look for dissociation which is intact performance on one task, but severely impaired performance on a different task related to localized brain damage. In a study by Calder et al. (2000) a subject had damage to the anterior portion of the amygdala. As a result this particular subject could not identify anything as disgusting. The subject had no ability to process disgust. Therefore any stimulus that would be revolting to someone such as the smell of rotting garbage, the subject would be unable to do describe it as disgusting or revolting. Therefore this neuropsychological evidence suggests that our emotional processing for disgust is confined to the anterior amygdala.

When looking at the different types of dependent variables and how to measure them, certain guiding analogies are used. As said before we utilize a multidisciplinary approach in cognitive psychology. The computer model from computer science is used as well as channel capacity from communications engineering. Channel capacity is that any channel, any physical device that transmits messages or information has a limited capacity, this would be referred to as bandwidth. This is useful when we look at retention and short-term memory. This is where we find that we have a limited number of items that we can pay attention to at any one time.

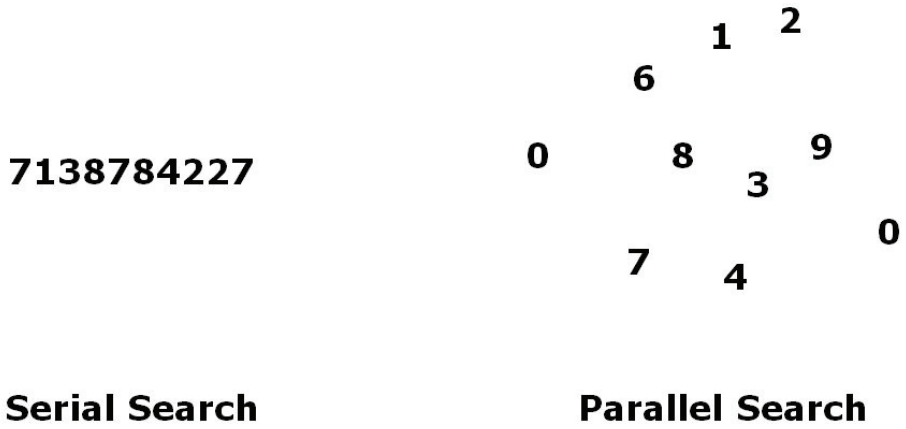
Guiding us using our computer analogy we look at how input processes and output processes in computers are very similar to human encoding and execution responses. In fact many theories in cognitive psychology are written similarly to computer programs. Often these theories resemble a precise form of code similar to programming language. This leads to the idea of a process model. When wanting to study some mental process, cognitive psychologists will develop a hypothesis. This hypothesis that is developed would be a specific set of mental processes or stages that takes place when performing a particular task. For example a lexical decision task is a common task used in cognitive psychology where manipulation of certain stimuli allows for a greater understanding of different stages of information processing. In the modern approach of lexical decision task we find five stages. In the lexical decision task subjects must pay attention to every word and then decide whether the word is a real word in their native language or not. For example if subjects were

to see the word cow they must decide whether that is a real, English word or not. If they were to see the word malarp they must determine that it is not a real word, something referred to as a nonword. The modern lexical decision task has five stages. Stage I is encoding where this is actual visual or auditory experience of the stimuli (i.e., seeing or hearing it). Stage II is a search or retrieval. This is where the subject starts accessing through the person's memory of words (also known as the lexicon) to see if that matches up to an already existing representation. Stage III is activation, this is where the already existing representation is activated or in the case of a nonword is not activated and that leads to stage IV. The decision based upon the level of activation determines whether we will say that something is a word or nonword. Stage V is an output function known as response execution. This is where a person might say aloud "real word" or say aloud "nonword", or press a button to indicate word or nonword. We often find that certain effects can relate to how this lexical decision occurs. For example word frequency, words that are encountered more often, have an effect on the search stage in terms of being much more easily and readily accessible therefore there is a shorter reaction time.



The lexical decision task. The stages at the beginning and end are calledperipheral stages. The stages in the middle are called central stages.

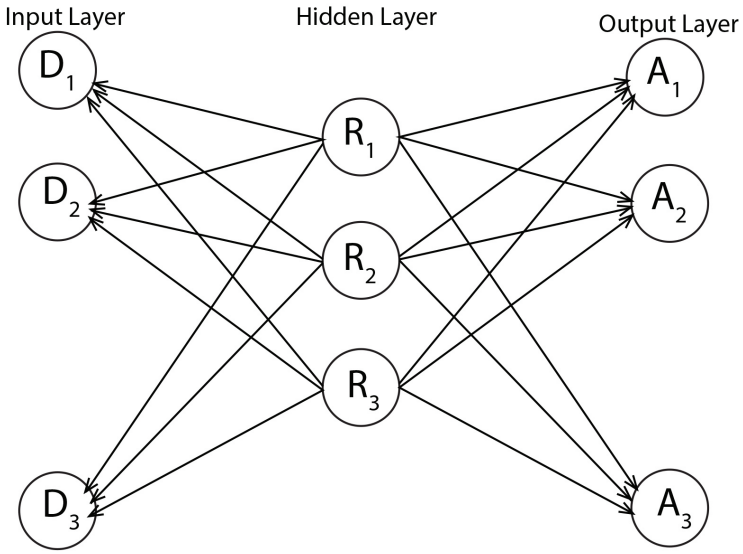
One way of viewing the information-processing approach in stages is often the idea of sequential stages of processing, the idea that each stage must be completed before another occurs. Recently this has been found to not be entirely true (Grabbe & Allen, 2012). Certain stimuli can automatically activate upcoming stages. This leads to more focus on parallel processing. We find in work by Lien et al. (2007) that there is evidence where activation of some stages occurs simultaneously. One way in which we see automatic activation is through contextual effects. Particularly when we find that if we encounter something in a similar context, encountering that context again will automatically activate the implicit memory. This will result in faster processing. This is often observed when we look at the priming of word categories. Such cases as if we were to prime somebody by mentioning the phrase of "animals" and then give a list of animals, that person will have an easier time than if we did not to mention animals at the beginning.



Such evidence of parallel processing dictates a revision of the computer model. The traditional interpretation of the computer model suggests strict serial processing in sequential stages. The idea is somewhat flawed here if we look at our other themes, the seventh theme of the brain, where we said before that any cognitive theory must be neurologically plausible. Neuroscience also suggests that parallel processing is possible and can be occurring in the brain; therefore many cognitive theories that preclude parallel processing may be incorrect and are in some need of being revised. This moves the field of cognition toward more modern theories, especially theories of more distributed computing such as neural-net models.



Neural-net models also known as connectionist models or parallel distribution processing models are computer-based techniques for modeling complex systems. In these models the brain acts not as one computer, but as many computers processing different bits of information of one large, overall problem. This also allows for both bottom-up and **top-down processing** to both occur simultaneously.



Neural-net models use multiple layers to model cognitive processes.

1.9 Neurobiology

Important for the understanding of cognitive psychology is the understanding of the brain. The brain is composed of small cells called neurons that are responsible for receiving and transmitting information. There are approximately 180 billion neurons in the brain. Of those, 80 billion are dedicated for cognition alone. Neurons come in two basic forms: receptor cells and effector cells. Receptor cells pass information along. Effector cells are responsible for the execution of action such as pushing a button or saying something. What is of profound interest is when the neurobiology of learning is examined. Learning is not the creation of new neurons (**neurogenesis**), which rarely happens in the brain, but the formation of new synapses. A synapse is a region where the axon terminus of one neuron and the dendrites of another neuron come together. The synapse is both a physical gap known as the synaptic junction as well as a functional relationship. When a synapse is referred to in cognitive psychology it is reflecting the idea that there is a functional, working relationship between two neurons and the passing of information. One neuron may synapse with as many as 100 to 15,000 different other neurons. The creation of new synapses as a result of experience is known as **plasticity**.

There are two basic ways of which neurons perform their job. Type one neurons cause other neurons to fire. Type II neurons inhibit other neurons and prevent them from firing. These are excitatory and inhibitory processes. They are important for the information processing by encouraging subsequent firing for continuous stages or the inhibition of the other synapses to reduce activation. Looking at examples of the lexical decision task in the case of a nonword, Type II neurons will fire in response to a nonword, which would cause a low level of activation in the third stage, which would lead to the decision that we do not have a representation for the current stimuli. Therefore it is a nonword.

At a synapse the neurons exchange neurotransmitters, which will have inhibitory or excitatory functions. The type of neurotransmitter used will also be reflected in the type of process that is occurring. For example in learning, dopamine is useful for reinforcement. Acetylcholine is used primarily in memory. We will also see amino acid neurotransmitters such as glutamate and GABA for excitatory and inhibitory processes respectively. When looking at the anatomy of the brain, the top layer of the brain is called the neocortex or cerebral cortex. It consists of four lobes named after the bones that they cover: the frontal lobe, the parietal lobe, the temporal lobe, and the occipital lobe. The occipital lobe is the primary visual cortex for processing visual information. The parietal lobe contains the somatosensory cortex and is important for body sensation and orientation. This is where we see a representation of the human body in terms of a proportional level of what is more sensitive. For example human beings hands and faces are overly represented because they have a high level of function associated with them and are using in fine motor behavior. The temporal lobe is the area associated with language and memory. The frontal lobe is for high levels of information processing particularly in decision making and working memory.

The brain is not a symmetrical organ itself. It is divided into two hemispheres based on the principal of contralaterality. Contralaterality refers the way in which the receptive and control centers for one side of the body are located on the opposite side or hemisphere of the brain. In this case functions carried out on the right-hand are processed in the left hemisphere. This leads to the topics of cerebral lateralization and hemispheric asymmetry. Functions tend to be on one side of the brain versus the other. For example in human beings the left hemisphere is associated with linguistic processing. Interestingly enough when looking at this is that most people are right-handed and therefore left hemisphere dominant. However many left-handed people are also left hemisphere dominant. The left hemisphere because of its linguistic human instinctual function is usually the dominant hemisphere.



Methods of neurological investigation. There are different ways of understanding the functions of the brain. In animal models the method of creating a **lesion** serves to isolate specific functions. Lesioning is to cause permanent brain damage by damaging a small select area of the brain and then noting any behavioral changes. Another way that is invasive but less damaging is direct stimulation. Pennfield applied minute electrical stimulation to the brain and would observe the reactions and outcomes. This is usually restricted to clinical settings where a person might be undergoing an operation on the brain. The experiments are carried out during the course of surgery (consent being obtained before the experiment).

Less invasive ways of studying the brain are looking at the structure and function of the brain using imaging technology. Computerized tomography or CT scans gives a view of the structure of the brain. In the desire to look at function many researchers look at magnetic resonance imaging and positron emission tomography. Both methods show activity in the brain. With MRIs the activity is actually looking at which areas of the brain are receiving higher or lower levels of blood flow. PET scans look at glucose which is tagged with a radioactive isotope. PET scans actually look at the metabolic activity of the neurons. The guiding hypothesis is that neurons that are receiving higher than normal flow of blood or are receiving glucose such as high metabolic activity are also neurons that are firing and are active within the cognitive processes there.



An MRI.



A PET Scan

A way of actually studying the behavior of the neurons itself in terms of the neurons firing, particularly polarization is electroencephalographs (EEG) and event-related potentials (ERPs). These involve measuring the activity of the brain using electrodes. There are certain wave patterns that form when processing various types of stimuli. One such wave pattern is the N400 wave. It is a negative wave pattern that occurs after a semantic anomaly. For example, the N400 wave will be elicited by a sentence that is syntactically correct, but semantically odd, such as "We saw the bus flying over the mountains." Since it is known buses do not fly, therefore that will register a semantic anomaly because flying is incongruous with the semantic representation for a bus. Syntactic anomalies produce a positive wave known as the P600 wave. This is where if somebody were to read aloud a sentence with a syntactic anomaly such as, "The wolverine ate the *the* caribou", the repetition of "the" produces a P600 wave because it is syntactically anomalous. New noninvasive techniques have used magnetic waves. **Transcranial magnetic stimulation** (TMS) is a technique in which magnetic pulses briefly disrupt the functioning of a given brain area.

1.10 Clinical/Applied Perspectives of Cognitive Psychology in WWII





During the Second World War scientists from a broad number of fields were called to assist on the warfront. Psychology was no exception and many psychologists assisted in the war effort. Although cognitive psychology was not yet formalized many psychologists were interested in cognition (the dissatisfaction with behaviorism was mounting). The founding of cognitive psychology later benefited from interactions psychologists had with other professions such as physics, mathematics, and engineering.

One of the theories that emerged from WWII was Shannon's Information Theory. Information Theory stated that information was communicated by sending a signal through a sequence of stages or processes. This experience of Shannon's led the way to the information-processing approach which is now so ubiquitous in cognitive psychology.

During WWII work by Alan Turning led to the development of modern computers. As a result not only did computers advance research such as data analysis and data collection, but also gave rise to computer modeling. Computer modeling is a hallmark of cognitive psychology. The advent of digital computers also resulted in research in **artificial intelligence**.

During WW2 many psychologists were recruited assisting in training of personnel particularly new technology required new training methods. Many academic researchers moved away from the sterile laboratory setting (and rats) to embrace field research with live human subjects. At the time new technology was emerging such as better aircraft and radar.

The response by behaviorist to the human interaction with this technology was ineffectual. One of the more prominent areas where this failure of behaviorism occurred was in the field of Signal Detection Theory. Signal Detection Theory is used still today. It was first applied to radar operators in understanding when and how radar operators detected incoming enemy aircraft. It became apparent that the reinforcement advocated by behaviorism was having no effect on the perceptual processes used by radar operators when determining if radar blips were friendly aircraft or enemy aircraft. A scientific perceptive that focused on performance (which later led to the field of human factors/human performance) was more effective. During this bleak time of war the budding field of cognitive psychology was able to not only assist in the war effort, but started to consolidate a definitive view for future research and acquired its multidisciplinary nature.

Stroop Task

A well-known test in cognitive psychology is this **Stroop task**. The Stroop task was invented in 1935 by John Ridley Stroop. This task utilizes different words that spell different colors, and the words themselves are also inked in different colors. In this task a participant must ignore what the word spells and pay attention to the color of the ink. In this situation we find tasks which are compatible such as the word red in the color red and incompatible such as the word red that is in green ink. In the Stroop task, what is found is that people have difficulty with the incompatible task. This shows automatic word processing. This has been shown to find that patients with frontal lobe damage have impairments in the ability to inhibit irrelevant stimuli. This has led to the understanding of the prefrontal cortex being involved in executive function that utilizes inhibition.



The Stroop task has been a mainstay of many experiments in cognitive psychology. It has been helpful in studying attention and inhibition.

Summary

The first psychologists were interested in the study of sensation, perception, and attention. Cognitive psychology as a discipline emerged in the 1950s and 1960s. Cognitive psychologists use models for studying cognition such as the computer model of cognition. Cognitive psychologists use empirical research methods and dependent variables such as reaction time and accuracy. Cognitive psychology has applications to real-world situations such as computer use and decision making. Pioneering work by Ebbinghaus advanced our understanding of memory and forgetting. Donders demonstrated how the use of logic can lead to experimental methods to measure specific cognitive processes.

Key Terms

cognitive psychology

cognitive neuroscience

ecological validity

Introspection

savings score

dissociation

lexical decision task

lexicon

top-down processing

neurogenesis

plasticity

lesion

Transcranial magnetic stimulation

artificial intelligence

Stroop task