Instant Notes

Cognitive Psychology

Jackie Andrade & Jon May

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Cognitive Psychology

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Cognitive Psychology

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BIOS Scientific Publishers
Taylor & Francis Group
LONDON AND NEW YORK

First published 2004

This edition published in the Taylor & Francis e-Library, 2005.

"To purchase your own copy of this or any of Taylor & Francis or Routledge's
collection of thousands of eBooks please go to www.eBookstore.tandf.co.uk."

A CIP catalogue record for this book is available from the British Library.

ISBN 0-203-48829-6 Master e-book ISBN

ISBN 0-203-59741-9 (Adobe eReader Format)
ISBN 1 85996 223 8 (Print Edition)

Garland Science/BIOS Scientific Publishers, 4 Park Square, Milton Park, Abingdon, Oxon OX14 4RN, UK and **29 West 35th Street, New York, NY 10001–2299, USA**
World Wide Web home page: www.bios.co.uk

Garland Science/BIOS Scientific Publishers is a member of the Taylor & Francis Group

Distributed in the USA by
Fulfilment Center
Taylor & Francis
10650 Toebben Drive
Independence, KY 41051, USA
Toll Free Tel.: +1 800 634 7064; E-mail: taylorandfrancis@thomsonlearning.com

Distributed in Canada by
Taylor & Francis
74 Rolark Drive
Scarborough, Ontario M1R 4G2, Canada
Toll Free Tel.: +1 877 226 2237; E-mail: tal_fran@istar.ca

Distributed in the rest of the world by
Thomson Publishing Services
Cheriton House
North Way
Andover, Hampshire SP10 5BE, UK
Tel.: +44 (0)1264 332424; E-mail: salesorder.tandf@thomsonpublishingservices.co.uk

Library of Congress Cataloging-in-Publication Data

Andrade, Jackie, 1964–
Instant notes in cognitive psychology / Jackie Andrade and Jon May.
p. cm.
Includes bibliographical references and index.
ISBN 1-85996-223-8 (pbk.)
1. Cognitive psychology—Textbooks. I. May, Jon. II. Title.

BF201.A53 2004
153--dc22
2003018482

Production Editor: Andrea Bosher

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Abbreviations

2.5D sketch	Marr's postulated 'two-and-a-half-dimensional sketch'
3D sketch	Marr's 'three-dimensional sketch'
AI	artificial intelligence
AIM	affect infusion model
ANM	associative network model
ASL	American Sign Language
cc	cubic centimetres
CCS	central conceptual structure
CRT	choice reaction time
EEG	electroencephalogram
ELM	elaboration likelihood model
ERP	event-related potential
fMRI	functional magnetic resonance imaging
FRU	face recognition unit
g	general intelligence
g_f	fluid ability
g_c	crystallized ability
GPC	grapheme–phoneme correspondence
IAC model	interactive activation and competition model
ICS	interacting cognitive subsystems
IQ	intelligence quotient
LAD	language acquisition device
LGN	lateral geniculate nucleus
LSD	lysergic acid diethylamide
LTM	long-term memory
m	meter
msec	millisecond
NP	noun phrase
PDP	parallel distributed processing
PET	positron emission tomography
PIN	person identity node
PL	phonological loop
PSYCOP	a 'natural deduction' model for reasoning, proposed by Rips (1994).
REM	rapid eye movement
RSVP	rapid serial visual presentation
SAS	supervisory attentional system
SIU	semantic information unit
STM	short-term memory
TLC	Teachable Language Comprehender
TODAM	theory of distributed associative memory
V	verb
VOT	voice onset time
VP	verb phrase
VSSP	visuo-spatial sketchpad
WAIS	Wechsler Adult Intelligence Scale
WISC	Wechsler Intelligence Scale for Children
ZPD	zone of proximal development

PREFACE

Cognitive psychology, the study of human thought processes, is an increasingly broad discipline. Conventional laboratory studies are now supplemented by research using new techniques of brain imaging and computer modeling. The result for students and teachers of the subject has been the need to choose between hefty textbooks that cover all aspects of the field in detail, but make it hard to see the wood for the trees, and shorter books that offer only partial coverage of the field. *Instant Notes in Cognitive Psychology* aims to cover all the key aspects of the subject in a succinct and structured format, enabling the reader to appreciate the important developments in the field and see how new findings can help to improve our understanding of human cognition.

Students new to cognitive psychology often find the topic rather abstract. It tends to be driven not by discoveries but by attempts to explain phenomena that are already known to us, for example how we suddenly hear someone mention our name in a noisy room or why we remember some things for years and forget others immediately. At first encounter, cognitive psychology can seem a way of making familiar things strange. The benefits of studying the subject are a deeper understanding of the complexity and beauty of the processes that enable us to perform mental feats that we take for granted. We have tried to make things easy for the reader new to the field by writing clearly, dividing the subject matter into manageable chunks, and providing signposts to related topics. We have taken particular care with two topics, emotion and consciousness, that are often poorly covered or neglected altogether by other cognitive psychology texts. These are two of the most exciting areas of psychological research and constitute core aspects of human mental life, influencing many aspects of cognition and contributing hugely to our sense of who we are.

We have written this book for undergraduates taking introductory psychology or more specialized cognitive psychology courses, A-level psychology students, postgraduate students or researchers entering psychology from other disciplines, and people studying for the cognitive psychology component of the British Psychological Society qualifying examination. The book can be used as preparatory reading, a revision aid, or a core text supplemented by lectures and further reading.

Reading this book before starting your course will give you an overview of the area, so that specific details can be readily assimilated as you encounter them. For those using this book as a core or supplementary text, we have provided two types of reference. It is important to know who had a good idea, when, and what they did to test it, so in the text we have cited the authors and dates of influential scientific papers and books. Learning names and dates may seem arduous, but it is common in psychology to refer to theories and studies by the names of their authors. These sources are listed in the references section at the end of the book. Reading these original references is beyond the scope of many basic level courses, so we have also included a further reading section that recommends more approachable texts.

To use this book as a revision aid, we recommend that you begin by reading the keynotes at the start of each topic to check if the topic was covered in your course and to help decide if you need to learn more about it. Then read the main text for more detailed information, checking that you understand the key terms highlighted in bold. Follow the links to related topics so you can see how the topic you are revising fits into the rest of cognitive psychology. Integrating information across modules and across different parts of a course is a way of showing that you really understand the topic and gets you good marks in exams. This book is designed to help you do this, with clearly marked links to related topics and sections. After revising a section, set it aside for a while then read the keynotes again to check you have remembered and understood the main points. Section A is intended to give an introduction to cognitive psychology and the methods used to research it. You may find it useful to read it again at the end of your course or revision period, to check that you really understand the nature of the discipline.

Jackie Andrade and Jon May

DEDICATION

To our parents, for their nature and nuture.

A1 Cognition

Key notes

Cognition

Cognition is the study of the mental processes underlying our ability to perceive the world, remember, talk about and learn from our experiences, and modify our behavior accordingly. It includes functions such as perception, memory, language and thought.

Assumptions about cognition

The mind is a limited capacity information-processing system that behaves in a law-like fashion. Cognition is the product of top-down and bottom-up processes. Top-down processing refers to the influence of knowledge and expectations on functions such as language, perception and memory. Bottom-up processing is processing driven by an external stimulus. Cognitive functions are often assumed to be modular, that is to operate independently of each other.

Philosophical basis

Functionalism views mental events as causal or functional because they serve to transform incoming information into output (different information or behavior). Mind is the 'software' of the brain and can be studied independently of it. For materialists, the mind is the brain and is studied by investigating brain activity directly. Choosing an approach is partly a matter of choosing an appropriate level of explanation for the topic of interest.

Related topics

Methods of investigation (A2)
Issues in consciousness research (K1)

Cognition

In 1967, Ulric Neisser published a book with the title *Cognitive Psychology*. Although scientists had been researching human thought from a cognitive perspective for a couple of decades before this, Neisser's book helped define cognitive psychology as a discipline. Neisser defined cognition as 'all the processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used.' Cognitive psychology is the study of the mental processes underlying our ability to perceive the world, to understand and remember our experiences, to communicate with other people, and to control our behavior. It comprises topics such as perception, attention, memory, knowledge, language, problem solving, reasoning and decision making, and aspects of intelligence, emotion and consciousness.

Think about reading this sentence. The rod cells of your retina respond only to light and the cone cells of your retina respond only to light of specific wavelengths. There is no type of cell in your eye that responds selectively to words. We cannot sense words directly. Rather, when you read this paragraph, your brain must transform the pattern of light reaching your retina into symbols representing words. These symbols trigger retrieval of word meanings from memory. To make sense of the text, you must also take into account the syntax or grammar of the sentences. But you are doing many other things too. You may be filtering out background noise and other sensations, such as the texture of the chair you are sitting on. You may be trying to remember if you have already learned anything about cognitive psychology. You may be deciding to take notes and recalling where you left your pen. You may be wondering if you will do well in your exams or worrying that you left the gas on. All this perceiving, understanding, ignoring, deciding, remembering, wondering and worrying is part of cognition.

Assumptions about cognition

Cognitive psychologists share some basic assumptions about the mind:

- The mind is viewed as an **information processing** system through which people interact with the external world. Information processing refers to the manipulation and transformation of symbols or representations of aspects of the external world. It can be represented by box-and-arrow flowcharts. Many cognitive theories have been represented in this way (e.g. Atkinson and Shiffrin's model of memory, shown in *Fig. 1* of Topic D2).
- The mind has resource and structural limitations, that is, it is a limited-capacity processor. Mental processes behave in a systematic, law-like fashion, hence we can investigate them by studying aspects of human behavior such as reaction times and error rates, and we can generalize from studies of small groups of people to humans in general.
- People are active processors of information. They do not respond passively to sensations but rather they use existing knowledge and mental skills to influence those sensations. In other words, our behavior is the result of **bottom-up** and **top-down processing**. Bottom-up processing begins with external input and travels 'up' through the cognitive system, for example, patterns of light hitting the retina are transformed into information about edges and thence into information about objects. Top-down processing refers to the influence of higher-level cognitive elements (goals, intentions, expectations, knowledge etc.) on lower-level processes (see Section B). For an example of the influence of expectation on perception, look at the picture of a duck in *Fig. 1*.

Many psychologists assume that cognitive processes are **modular**. Modules are clusters of processes that function independently from other clusters of processes. Each module processes one particular type of information, for example visual objects or faces. The assumption of modularity means that cognitive psychologists do not have to be experts in all aspects of cognition simultaneously. Rather, they can study in detail one aspect of cognition, for example visual object recognition or face perception. Modularity also underpins the assumption of **localization of function**, that mental processes map onto specific regions of the brain. Therefore, studying the effects of damage to specific brain regions can tell us about normal cognitive functions (see cognitive neuropsychology in Topic A4). However, modularity can also emerge from the activity of distributed, rather than localized, networks of neurons. This means that modular cognitive functions can be mimicked by connectionist networks (see cognitive science in Topic A4; also Topic E4).

Philosophical basis

A philosophical approach called **functionalism** underpins cognitive psychology. It assumes that mental processes and states are functional, that is, they

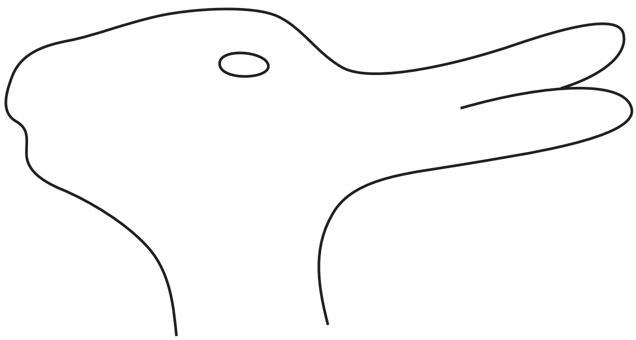

Fig. 1. People can see this ambiguous figure as a duck or a rabbit. The expectation that it was a figure of a duck should have made you see it first as a duck rather than a rabbit, and may make it difficult to 'reverse' your perception to see it as a rabbit.

cause input information to be transformed into output information or behavior. Functionalists propose that the relationship between the mind and brain is analogous to the relationship between the hardware and software of a computer. The most productive way to study human thought and behavior is to study the 'software' of the mind. An alternative approach is **materialism**, the view that the mind and brain are identical therefore human thought and behavior can be understood by studying neural activity in the brain. The two views are not mutually exclusive. Indeed, cognitive psychologists almost invariably hold both. However, whether you are a functionalist or a materialist at heart determines the approach you will prefer for investigating the mind. Functionalist approaches focus on explaining human behavior in terms of information processing and mental functions, whereas materialist approaches focus on reducing mental processes and states to their underlying neural anatomy and biochemistry. Which approach to choose is partly a question of deciding the appropriate **level of explanation** for the phenomenon of interest. For example, the Mediterranean can be described in terms of its geography and tourist industry or in terms of the chemistry of the weak hydrogen bonds that give water its unique properties. One description is better for explaining its economy, the other for explaining its wetness. Memory can be explained in terms of processes such as rehearsal and retrieval (see Section D), or in terms of neurotransmitter release and changes in synaptic sensitivity. The first, cognitive, level of explanation is better for understanding how best to revise for a psychology exam, the second helps explain how the apparently homogenous squishy mass that is your brain can learn and adapt.

Ultimately, we need both types of explanation, functional and biological. With this in mind, Marr (1982) proposed a framework for characterizing cognitive theories. The highest level of explanation, the **computational level**, requires specification of the functions of the cognitive phenomenon under investigation, for example the goals of its component processes and the context in which they operate. The **algorithmic level** requires specification of how the computations or functions can be carried out, for example how the input is represented and the details of how it is transformed into output. The lowest, **hardware level** explains how the algorithm is implemented physically, for example, how individual neurons or neural systems perform the computations specified at the algorithmic level.

A2 METHODS OF INVESTIGATION

Key notes

The science of cognitive psychology

Cognitive psychology involves developing theories about human thought processes, deducing hypotheses, and testing predictions based on those hypotheses. Often a hypothesis is tested by several methods to give converging evidence for or against a theory. At least some tests of a theory should be ecologically valid, that is, the test conditions should conform closely enough to real world conditions that we can conclude whether the theory holds true in 'real life'. An additive model of cognition, which assumes serial processing, is often the basis for designing experiments to discover how long a particular cognitive process takes or what happens to task performance when a particular process is prevented.

Research ethics

All research must be ethical. Participants must know what they are volunteering for, must be free to withdraw at any point, must not be caused harm or distress, and must be debriefed at the end of the experiment so they leave with an understanding of what was done and why. Researchers are responsible for ensuring the sound conduct and reporting of research.

Empirical methods

Experimental methods test the effect on cognitive performance of manipulating stimuli or conditions, whereas correlational approaches investigate the relationship between different cognitive functions. Statistical analysis helps distinguish the effects of interest from fluctuations in performance that are due to chance or other variables.

Related topics

Cognition (A1)

The history of cognitive psychology (A3)

The science of cognitive psychology

Like the rest of psychology, cognitive psychology is a science. It involves systematically investigating human thought by developing and testing theories. Here are some terms you will encounter in this book:

- A **phenomenon** is the problem or aspect of behavior that interests you. For example, a visual illusion or people's ability to hear someone mention their name above the background noise of a party.
- A **theory** is an integrated set of assumptions and statements about the phenomenon of interest. Theories serve two purposes: i) they **explain** what we already know about the phenomenon, often integrating diverse data sets by postulating general, underlying principles or mechanisms; ii) they enable us to **predict** new information. Theories must be **testable**, that is, they must give rise to specific predictions that can be disproved or **falsified**. Marr's theory of vision is an example (see Topic B4).
- A **paradigm** is the global set of assumptions shared by a community of researchers, including the shared theory or theories, assumptions about

which are the important aspects of the phenomenon under investigation, and assumptions about the best methods for studying the phenomenon. Connectionism (see Topic E4) and cognitive neuropsychology (see Topic A4) are examples. The term 'paradigm' is often used in another sense in cognitive psychology, to mean a research method or technique.

- A **framework** is a general set of principles for understanding a phenomenon or conducting research. It is a useful set of guidelines rather than a testable theory. Craik and Lockhart's levels of processing framework is an example (see Topic D3).
- A **model** is a testable set of propositions about a phenomenon. The terms 'model' and 'theory' are often used interchangeably, though 'model' is usually reserved for explanations with more limited scope. For example, decay theory (see Topic D3) is a claim about general memory function whereas the working memory model (see Topic D2) is a claim specifically about how we temporarily store and process information during complex cognitive tasks.
- A **hypothesis** is a testable proposition, derived from a theory or model.
- A **prediction** is a statement about how the world will behave in a particular circumstance.
- An **experiment** is a means of testing a hypothesis about the effects of certain variables on behavior by manipulating those variables, while holding others constant.
- **Empirical research** or **empiricism** is the building and testing of theories through observation and experimentation (contrast **rationalism**, which is the development of theories from first principles). Cognitive psychology is an empirical science.

As an example of theory development in cognitive psychology, consider the changes in our understanding of short-term memory (discussed in more detail in Topic D2). In the 1960s, Atkinson and Shiffrin proposed a model of memory in which short-term storage of information was separate from long-term storage. They hypothesized that the short-term store functioned as a 'working memory', that is, that it did not merely hold information for brief periods so people could do well in short-term memory tests, but rather that it held information in a form that could be used for complex cognitive activities such as problem solving or reasoning. Baddeley and Hitch tested this hypothesis. They asked participants to remember a string of digits while performing a reasoning task. They predicted that the concurrent digit memory task would impair performance on the reasoning task. In fact, performance on the reasoning task was impaired very little by the digit memory task, much less so than would be expected if both tasks competed for the same limited-capacity store. This finding therefore falsified the hypothesis of a unitary short-term store that functions as a working memory. On the basis of their research, Baddeley and Hitch developed a new model of working memory, comprising separate storage systems (used for remembering the digits in their experiment) and a processing system (used for complex tasks such as reasoning). The new model led to new hypotheses, for example that there are separate visual and verbal storage systems, and new predictions, for example that verbal tasks will interfere more with verbal short-term memory than with visual short-term memory. Empirical tests of these predictions have generally found them to be correct. For example, experiments have shown that repeating 'the the the …' impairs short-term memory for words more than short-term memory for pictures or locations.

The fact that many experiments have supported the predictions made by the working memory model does not mean that the model is true, that it gives an absolutely accurate account of human memory function. An experiment we run tomorrow may still disprove some aspect of the model. Therefore we cannot say that the theory has been proved, merely that it has not been falsified yet. Data that support a prediction are said to **corroborate** the theory, rather than to prove it. Failing to falsify a theory is a useful thing to do – a corroborated theory is better than an untested theory or a falsified theory, and the more experiments we run, the better will be our understanding of the phenomenon and our ability to generate new predictions.

What happens if an experiment produces data that falsify a hypothesis? One option is to modify or abandon the original theory. Another is to question the experiment, to ask whether there is some aspect of the experiment that led to the anomalous result even though the theory may be true. Maybe participants failed to follow the instructions they were given or maybe their preconceived ideas about the topic of investigation distorted their behavior. A solution to this problem of knowing how to deal with anomalous data, and the problem of not being able to prove a theory conclusively, is to test theories in many different ways. **Converging evidence** from a variety of sources helps to strengthen a theory. A theory that has survived a concerted attack from laboratory experiments, neuropsychology, computational modeling and so on is generally considered better than one that has support from only one source. Different empirical methods are considered next, and in Topic A4.

Laboratory-based research enables us to test theories under carefully controlled conditions, so we can be confident that we have taken all the relevant variables and alternative explanations into account. However, for psychology to be an interesting and worthwhile pursuit, it must tell us about how people behave naturally, not just how they behave in the laboratory. It is therefore important that some tests of a theory are **ecologically valid**, in other words that they test whether the theory applies to real-life conditions. To continue with our working memory example, an important aspect of working memory is that it not only stores information for short periods (i.e. that it functions as a short-term memory) but also that it uses that information to support complex cognitive tasks (i.e. it functions as a working memory). Laboratory studies have supported the claim that working memory is involved in a range of complex cognitive tasks, showing mutual interference between tasks that are assumed to require working memory but are otherwise quite different (e.g. problem solving and random number generation; see Topic D2). Research into the use of telephones while driving provides a real-world demonstration of this. Initially, hands-free cellular phone systems were assumed to be safe for use in cars because talking and driving were sufficiently different activities (one verbal, one visuo–spatial) that they should not interfere. However, both tasks also have a working memory component, both requiring monitoring, planning, retrieving information from long-term memory etc. Using a telephone requires keeping track of the conversation, comprehending what is spoken, planning and remembering what to say next, visualizing the other speaker. Driving requires keeping track of one's position relative to other cars, comprehending road signs and monitoring the general situation (e.g. road works, junctions, speed limits), planning maneuvers (when to signal, turn etc.) and recalling one's route. This analysis makes it less surprising that research shows that telephoning impairs driving performance. In a study that predates the current popularity of mobile phones by several decades, Brown, Tickner and Simmonds (1969) found that comprehending and verifying complex sentences impaired drivers' judgments of whether a gap was wide enough to drive through. More recently, Strayer and Johnston (2001) showed that conversations on hands-free cellular phones made people slower to respond to traffic signals in a simulated driving task.

Many controlled experiments, whether laboratory-based or real-world, are based on an **additive model** of cognition. This assumes that if you add a component to a task, then any behavioral changes (in reaction times or error rates) are attributable to the added component. Imagine you are asked to watch a display of lights and your task is to press a key each time a green light flashes. In the first version of the task, every light is green. Let's say your reaction time is 300 msec. That is how long it takes to make a response to a stimulus. In the second version of the task, some lights are red and you press a different key for those. Let's say your reaction time to the green lights is now 500 msec. That is how long it takes to decide which response to make and to make that response. The difference of 200 msec is therefore assumed to reflect the time taken to decide which response to make.

There are several pitfalls with the additive model. One is that it assumes cognitive processes are serial, that we complete one before starting the next. In the example above, we assume that we finish perceiving the stimulus before deciding which key to press. In fact, we may start preparing our response before we are absolutely sure that the light is green (or red). Another problem is that adding or subtracting a process can radically alter a task. For example, researchers of verbal short-term memory (see Topic D2) sometimes ask participants to repeat 'the' aloud while trying to remember lists of words. They assume that their performance on the memory task then reflects how well they can store words in verbal memory without rehearsing them. In practice, however, participants may change their strategy and use visual rather than verbal short-term memory, remembering the written form of the words or forming images of the things they refer to. An increase in errors in the 'repeating the' condition may reflect either the removal of rehearsal from a verbal memory task or a switch to a visual strategy that is less effective for remembering verbal stimuli. This problem is pertinent for cognitive neuropsychology, where brain damage may alter how people tackle tasks rather than simply removing their ability to do one aspect of a task, and cognitive neuroscience, where brain imaging studies subtract brain activity on control tasks from brain activity on the task of interest (see Topic A4).

Research ethics

All research must respect the rights of the research participants. It must avoid causing them harm or distress. Before starting a study, researchers typically submit a description of their planned research to a local research ethics committee, which follows ethical guidelines published by national bodies such as the British Psychological Society and the American Psychological Association. Although cognitive psychology experiments may generally seem fairly innocuous, there are still ethical pitfalls. For example, if you want to see how much people remember incidentally, without trying to, then you may want to give them a surprise memory test. This involves an element of deception, because you cannot warn participants in advance that their memory will be tested. Indeed, you may use a **cover story** (a fictitious account of the aims of the experiment) to distract them from the real purpose of the experiment. At the end of the experiment, it is important to explain to them why the deception was necessary, not least because you do not want them to try to remember everything in every subsequent psychology experiment they take part in, just in case there will be a surprise memory test. This explanation at the end of an experiment is called **debriefing**. Some cognitive psychology research can be stressful because it involves looking at distressing images or hearing threatening words. In such cases, participants should be warned that the experiment involves such stimuli. If an experiment involves a manipulation of mood (e.g. see Topic L2), then it is important to reverse that manipulation in case it adversely affects behavior outside the test environment.

Key elements of ethical conduct of research include:

- Ensuring that participants are told enough about the study in advance that they can give **informed consent** to take part in it. In psychological research, this can require careful judgment. Telling people too much about the aims of the experiment can lead them to try to behave in the way they believe the experimenter wants them to behave, rather than behaving 'naturally'. This is known as responding to the **demand characteristics** of the experiment. Telling people too little about the experiment not only prevents them giving truly informed consent, but also encourages them to form their own hypotheses about the aims of the experiment and to behave in apparently bizarre ways to satisfy those aims.
- Informing participants that they may refuse to take part or may withdraw from the study at any time without giving a reason and without adverse effects (e.g. without compromising their treatment in a medical study).
- **Debriefing** participants at the end of the study. Debriefing means explaining why the experiment was conducted, revealing any hidden manipulation or deception, and reversing any manipulations of mood or beliefs.

As in all sciences, psychological research must be scientifically ethical. Scientists have a social duty to report methods and data accurately and truthfully. Most journals require authors to keep their data for 5 to 10 years from the date of publication, so they can be re-analyzed in the event of a query. The authorship of scientific papers includes all (and only) the researchers who have made an intellectual contribution to the conduct or reporting of the research. All authors are deemed responsible for the content of the paper and for the good conduct of the research reported therein.

Empirical methods

One of the difficulties in testing cognitive theories is that we can only do so indirectly. This problem is not peculiar to psychologists. For example, physicists interested in elementary particles cannot observe them directly, but must infer their behavior from their effect on the environment, for instance in a bubble chamber. Similarly, psychologists cannot see cognitive processes in action but must infer their operation from people's behavior. The problem here is that people vary – they differ in their interest in the experiment, in how well they concentrate, in how much they already know about psychology, and a host of other variables. One solution to this problem is to use carefully designed experiments to minimize the influence of individual variation on the measure of interest. Another is to take advantage of the variation by testing whether the behavior you are interested in correlates with another variable that you already know something about, or to test the differences between two very different groups of people.

As an example, imagine you want to test the hypothesis that verbal information is maintained in working memory by a sub-vocal rehearsal process:

- An **experimental** study might involve testing three groups of people. One group simply remembers lists of words for immediate recall. This is a control group; their performance tells us about 'normal' performance on the memory task. A second group tries to remember lists of words and performs a non-verbal task, for example tapping a pattern on a keyboard, at the same time. This is another control group; their performance tells us about memory performance with general distraction. A third group tries to remember the words while performing a task that blocks the hypothesized sub-vocal rehearsal process, such as repeating 'the' aloud. This is the experimental group. Comparing their performance with the two control groups tell us how much repeating 'the' impairs their verbal memory performance, how much of the impairment is due to the general difficulty of having to perform two tasks at once, and how much is due to the specific demands of performing two verbal tasks at once.

  One way of running this experiment is to test every participant in every condition, so each volunteer does the memory test in the experimental condition and both control conditions. This is called a **repeated measures** design because we measure each person's performance repeatedly. The advantage of this design is that it minimizes the effects of individual variation because each person acts as their own control. However, it introduces new sources of variation, for example participants may get tired towards the end of the testing session or they may develop new strategies for remembering the words. An alternative is to use a **between groups** design, assigning a third of participants to each condition. The effects of individual differences are minimized by testing many people in each group and by randomly assigning participants to the different conditions. Because these designs control for individual variation, their results should tell us about cognition in general, not just about the cognitive processes of these individuals. Thus, although many cognitive psychology experiments are conducted on undergraduate psychology students, their results can be extrapolated to people in general.
- A **correlational** study aims to test a sample of people who vary widely. To test the sub-vocal rehearsal hypothesis, one could use a correlational study to discover whether rehearsal speed, that is, speech rate, predicts verbal memory performance. A good sample would be children of different ages because speech rate increases as children get older. Some researchers have done this and found a strong correlation between speech rate and verbal short-term memory, supporting the hypothesis that the faster you can speak, the more words you can rehearse before your memory for them fades. A variation on this study is to compare two groups of people who vary in speech rate, for example younger and older children or people using their native versus a second language.
- With either type of study, we still need **statistical analysis** to tell us what the data mean. In an experimental study, performance in the different conditions will differ simply because people rarely get identical results each time they are tested. We need statistical tests to tell us whether the differences between scores from the different conditions are real, or merely the result of chance fluctuations in performance. In correlational studies, we need statistical tests to tell us the strength of the relationship between speech rate and memory scores.

A3 THE HISTORY OF COGNITIVE PSYCHOLOGY

Keynotes

Precursors — Precursors of cognitive psychology were introspectionism, which aimed to understand mental processes through training people to report the details of what they were thinking, and behaviorism, which aimed to explain how different stimuli caused different behaviors without recourse to hypothetical mental events.

Early days — Applied problems about human performance on military tasks, combined with the new computer metaphor (where brain is hardware and mind is software) and new theories in linguistics, stimulated a move towards a systematic study of mental functions.

Recent developments — Recent developments have included greater cross-talk between psychological disciplines, resulting in new sub-disciplines such as cognitive science, cognitive neuropsychology, and cognitive neuroscience.

Related topics — Methods of investigation (A2); Sub-disciplines of cognitive psychology (A4); Early approaches (F1)

Precursors

In Leipzig in 1879, **Wundt** established the world's first experimental psychology laboratory. His trained observers used **introspection** ('looking into' their minds) to report on their experiences of stimuli. Wundt evaluated their emotional states and measured their reaction times. He emphasized that conscious experiences are more than the sum of their parts, and more than simple passive responses to stimuli. In 1912 Wertheimer extended this approach into **Gestalt psychology**, arguing that mental activity is directed at whole forms rather than component parts of forms, hence *Fig. 1* is typically perceived more quickly as an H and than as an array of Ts (see Topics B4 and B5). Another extension of Wundt's approach was his student Titchener's use of introspection to draw conclusions

```
T       T
T       T
T       T
T       T
TTTTTTTTT
T       T
T       T
T       T
T       T
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Fig. 1. We perceive the H faster than the Ts.

about the structure of thought, an approach known as **structuralism**. Titchener presented himself as a proponent of Wundt's ideas (e.g. by translating selected parts of Wundt's works from German into English) but his aim of defining the basic components of thoughts conflicted with Wundt's emphasis on whole experiences. The use of introspection fell out of fashion for three reasons: i) new research showed the importance of unconscious, and hence unreportable, processes in vision (Helmholtz) and personality (Freud); ii) unresolvable conflicts between laboratories, such as the **imageless thought controversy** in which trained observers disagreed about whether thoughts were always accompanied by mental images; iii) the increase in interest in the study of mental processes and their functions (rather than structure), known as **functionalism** or **functional psychology** (to distinguish it from the philosophical position). Proponents of functionalism included James, who emphasized the continuous flow of mental processes or 'stream of consciousness', and Dewey, who argued that behavior should be considered as the process of an organism adapting to its environment.

Functional psychology helped push psychology away from studying mental experiences and towards studying behavior. It thus set the scene for **behaviorism**. Behaviorists such as **Watson** and **Skinner** argued that psychology should be concerned only with measuring objectively observable behaviors and with determining stimulus–response relationships, not with studying mental properties such as consciousness. Other behaviorists, such as **Hull** and **Tolman**, included a role for intervening but unobservable mental events in stimulus–response associations.

Early days

Behaviorism dominated North American psychology until the 1970s. Now cognitive psychology is probably the dominant approach in both America and Europe. European interest in studying mental processes for their own sake developed much earlier, stimulated in part by the demands of World War II for a better understanding of **human factors**. The term 'human factors' refers to the human abilities and weaknesses that affect task performance, as opposed to factors such as equipment design. The Unit for Research in Applied Psychology was established in Cambridge UK in 1944 for researching military problems such as pilot fatigue and vigilance in radar operators. When its first director, **Craik**, was asked to develop a model of gun-aiming, he responded by analyzing the problem in terms of the information received by the operator, the processes they had to carry out, and the responses they had to construct. Defense needs, and defense funds, also stimulated later research on selective attention and auditory discrimination, which had implications for applied problems such as those faced by sonar operators trying to distinguish submarines from shoals of fish. A classic example of psychological theorizing from the middle of the 20th century is **Broadbent**'s model of how information is filtered before undergoing further processing and storage (see Topic C1).

Other movements in the 1950s and 1960s helped establish cognitive psychology as a discipline. In **linguistics**, **Chomsky** (see Topic H1) proposed that language is innate, that children are born with a mental grammar that forms the basis for language learning. His proposal of a mental mechanism for understanding language radically and explicitly opposed Skinner's behaviorist theory that we learn language through repeated experience and reinforcement of associations between objects and their names. Developments in computer science helped establish a metaphor for theorizing about cognitive processes as the brain's 'software'. The availability of much greater processing power facilitated developments in statistics, providing new ways of analyzing complex psychological data. **Information theory**, a mathematical approach to explaining the constraints on communication of information, influenced the new theories of cognition that describe the flow of information through the mind.

Recent developments

Although cognitive psychology has been influenced by case studies of the effects of head injury from its early beginnings, and in recent years by computer science, a characteristic feature of the discipline at the start of the 21st century is greater cross-talk with other disciplines. The increasing influences of computational models, systematic studies of brain damage, and new *in vivo* brain imaging techniques have resulted in new sub-disciplines such as cognitive science, cognitive neuropsychology, cognitive neuroscience, social cognitive neuroscience etc. Verbal or qualitative models of information processing are still the foundation stones of mainstream cognitive psychology, but it is increasingly common for them to be supported by evidence from brain-injured patients and quantitative (computational or mathematical) modeling as well as by conventional laboratory experiments. The main sub-disciplines of cognitive psychology are discussed in the next Topic.

A4 SUB-DISCIPLINES OF COGNITIVE PSYCHOLOGY

Keynotes

Cognitive science

Essentially the development of computational models of cognitive functions, as a means of learning more about human cognitive abilities. The aim is to program a computer with the same competence and performance as a human. Strong artificial intelligence (AI) assumes that a correctly programmed computer will be conscious in the same way as a human. Weak AI assumes that a correctly programmed computer just simulates human consciousness.

Cognitive neuropsychology

The study of cognitive deficits following brain injury has strongly influenced the development of cognitive theories. Double dissociations in patterns of impairment support claims that cognitive functions are modular. A criticism of this approach is that studying the effects of something's absence does not reveal its function when present.

Cognitive neuroscience

This new approach uses brain imaging techniques such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) to study intact brain function. It is based on the assumption that separate cognitive functions are properties of separate brain regions. Studies are informed by neuropsychology and cognitive theory.

Applied cognitive psychology

Uses cognitive theories to explain performance in real-world rather than laboratory settings. Cognitive psychology helps solve applied problems; applied problems in turn help test the generalizability of cognitive theories.

Related topics

The history of cognitive psychology (A3)
Limits and failures of memory (D4)
Connectionism (E4)
Dyslexia (I4)

Cognitive science

Artificial intelligence (AI) researchers attempt to program computers to replicate human capabilities, for example, robots that can move around their environment and 'see' obstacles in their way. Cognitive science is a marriage between artificial intelligence and cognitive psychology. Cognitive scientists develop computational models of cognitive functions as a means of discovering more about human cognition. They work from the functionalist assumption (see Topic A1) that cognitive functions can be studied without direct reference to the material brain and, indeed, that they can be implemented in any hardware with appropriate computing power. Some take the view known as **weak AI**, that there may be something special about biological brains and sensory systems but that computational models are nonetheless useful tools for improving our theories of cognition. Others hold the **strong AI** position, assuming that a correctly programmed computer will think and be conscious in the same way as a human.

Cognitive scientists aim to program computers with the same **competence** as a human (i.e. the program makes realistic assumptions about how the human brain works) and the same **performance** (i.e. the same pattern of successes and errors on a task). Typically, a qualitative (verbal or flowchart) model of human cognition serves as the basis of the computer model. The computer model is tested by comparing its performance against data from human experimental studies.

Computational modeling is a useful means of testing cognitive theories. Finding that the computer model performs similarly to humans does not prove that the underlying cognitive theory is correct, but shows that the theory gives at least a possible account of the cognitive processes under debate. Finding that the performance of the computer model is unlike that of humans shows that the underlying theory is wrong. Computational modeling is also important because it stimulates better specification of cognitive theories and generates new predictions. For example, conventional accounts of short-term memory describe the need for rehearsal to offset decay of information in temporary storage. However, they do not specify how that rehearsal takes place (how often is each item rehearsed? in what order are items rehearsed?) or how retrieval happens (how do we know where the start of the list is? what happens when we cannot remember an item?). These questions must be solved before a computer can be programmed to mimic accurately human performance on a short-term memory task. A key problem is how, during a serial recall task, we know which item comes next in the sequence. Some solutions to this problem are outlined at the end of Topic D2.

Cognitive neuropsychology

Cognitive theories can be tested by studying the pattern of preserved and impaired cognitive performance after brain injury. If a theory postulates that, say, language production and language comprehension are separate functions, then it should be possible to find people with one sort of brain injury who have difficulty speaking but not comprehending, and people with another sort of brain injury who have difficulty comprehending but not speaking (see Aphasias in Topic H4, and Topics D2 and D4 for other examples). This pattern of data would be an example of a **double dissociation** and supports the assumption of modularity of cognitive functions (see Topic A1). Cognitive psychology and neuropsychology are mutually beneficial – cognitive theories can help explain individual patients' difficulties with particular tasks and, by improving understanding of their condition, help suggest strategies for rehabilitation.

A criticism of cognitive neuropsychology is that studying the effects of something's absence does not reveal its function when present. By analogy, removing sections of track from a railway may cause chaos, but the function of the track is not related to the chaos caused. A difficulty with the approach is the scarcity of people with very localized brain damage that impinges on specific cognitive functions.

Cognitive neuroscience

Cognitive neuroscience is the study of cognitive functions using new imaging techniques such as **positron emission tomography** (PET) and **functional magnetic resonance imaging** (fMRI) to study brain function *in vivo*. These techniques reveal which brain regions are most metabolically active (e.g. which