COGNITIVE PSYCHOLOGY

REVISITING
THE CLASSIC STUDIES

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1 An introduction to classic studies in cognitive psychology

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THE CLASSIC PAPERS IN COGNITIVE PSYCHOLOGY

Of the hundreds of thousands of papers and other publications on cognitive psychology published over the years, just a few stand out as 'classics'. These are the studies which shaped the way that cognitive psychology would develop in the years to come. They became classics because they introduced some new theoretical framework or experimental procedure which would influence cognitive theory and research in the future.

This book traces the way in which classic studies in cognition have led us to the very latest research going on today. We have chosen 14 studies which in our opinion deserve to be considered classics, because they provided a new approach to some aspect of cognitive psychology. Each study provided the starting point for a wealth of research in subsequent years. We wanted our book to reflect how the classic studies have influenced today's research, so we selected 14 researchers currently among the leaders in the field relating to each study. We then asked them to write a chapter on the relevant classic study, explaining its influence on subsequent research.

Selecting the classic studies obviously involved a certain amount of personal opinion. We are sure there will be other studies you think should have been included, and probably some we have included you think should have been excluded. However, we tried our best to pick the ones we believe have had the most influence on subsequent research. Of course, many important studies and theories have failed to stand the test of time. Many theories were proposed which eventually proved to be incorrect, and many new procedures were introduced which were popular for a time but which have now outlived their usefulness. Such studies have not been included in this book because they are no longer relevant to current research. We have restricted our list of classics to those having contemporary relevance, the key studies which steered cognitive research in a new direction and which still influence research today.

The first scientific experiments in cognitive psychology were performed in the latter part of the nineteenth century. Early pioneers included Wilhelm Wundt, who opened the world's first laboratory of psychology in Leipzig in 1879 and carried out some of the earliest experiments on perception, and Hermann Ebbinghaus (1885), who carried out the first scientific experiments on memory. Many more experimental studies followed, some of which took cognitive psychology in new directions. The Gestalt group added important findings on the perception of shapes and figures (Wertheimer, 1912), and also carried out early studies of thinking and problem solving (Köhler, 1925). Bartlett (1932) contributed key findings about the significance of meaning and knowledge on memory. All these early contributions could be considered classic studies in their time. However, they are mainly of historical interest as they involved theories and methods no longer particularly relevant to current research. For this reason we have excluded them. As we stated above, the aim of our book is to revisit the classic studies which laid the foundations of today's cognitive research, and then to trace the development of that research right up to the present day.

The study of cognitive psychology was initially held back by the prevailing influence of behaviourism, whose protagonists argued that mental processes could not be directly observed and were not therefore open to scientific study. They concluded that mental processes should be excluded from the discipline of psychology altogether (Watson, 1913; Skinner, 1938). However, we must not exaggerate the baleful influence of behaviourism. Some behaviourists (especially, for example, Tolman, 1932) argued that theorists should focus on *intervening variables* referring to internal processes mediating the effects of stimuli on responses. Of special relevance to cognitive psychology was his notion of 'cognitive map' (Tolman, 1948), according to which even rats store away integrated spatial representations of their environment.

It was not until the 1950s that cognitive psychology began to emerge from the shadow of behaviourism and started to establish itself as a truly scientific discipline within mainstream psychology. A new generation of cognitive psychologists devised ways of investigating cognition and mental processes scientifically. This changed the nature and subject matter of our discipline so dramatically that it has often been called the 'cognitive revolution'. It is mainly from this period that we have chosen our first 'classics'.

THE 14 CLASSIC STUDIES

A number of studies published in the 1950s set the stage for today's cognitive research. One of the first was carried out by **Cherry (1953)**, who devised a new method of investigating how we direct our attention. Colin Cherry used a procedure known as dichotic listening, whereby a set of headphones was used to direct different messages to each ear. The participant attended to one message and ignored the other, but Cherry was mainly interested in the fate of the unattended message. He discovered that very little of the unattended message was perceived,

as it was apparently processed at only a very basic level, not extending to meaning. Cherry's study began a whole new approach to the study of selective attention, and this research continues to the present day. We have therefore included Cherry's paper in our list of classic studies, and you will find a detailed account of Cherry's work and its influence on subsequent research in Chapter 2.

Another important study of this period was that of **Gibson (1950)**, who was interested in the way we extract information from our surroundings. James Gibson argued that the perceptual system is capable of detecting patterns in the incoming sensory array, which enable the individual to grasp the nature and potential uses of objects in the world around us in the absence of mental interpretation. Gibson's view of perception therefore focused on 'bottom-up' processes, which contrasted with the previously popular view that the organism can only make sense of the world by processing the new input in a schema-driven or 'top-down' fashion. His approach was also strikingly original in that he argued that the main function of perception is to move around the environment and to respond to the actions of others. This differed radically from previous empirical approaches in which participants were required to keep their heads still while visual stimuli were presented. Gibson's study has become a classic, making a lasting impact on the study of perception. Gibson's study and its subsequent influence are discussed in detail in Chapter 3.

Marr (1982) proposed a highly influential theory of object recognition based on a computational approach. He assumed that the brain recognises objects by subjecting them to an information-processing mechanism similar (but not necessarily identical) to the processing carried out by a computer. Marr suggested that a new sensory input is subjected to several different stages of processing and analysis, with each stage producing an increasingly detailed and complete representation of the stimulus. Marr's theory was strongly influenced by analogy with computer programs, and has led to extensive research on the computerised simulation of object recognition. You will find an account of Marr's study in Chapter 4.

Goodale and Milner (1992) demonstrated that perceptual processing actually appears to involve two separate processing mechanisms analysing different aspects of the same visual input. They studied a brain-damaged patient unable to identify objects visually, but who retained a relatively unimpaired ability to identify their location. From this finding, Goodale and Milner concluded that there are two separate pathways from the visual cortex, each having different functions. The ventral pathway (the one damaged in their patient) appears to be concerned with object identification and shape, while the dorsal pathway is concerned with spatial location. Goodale and Milner's study is described in Chapter 5.

Some studies were not recognised as classics when published and so remained largely ignored until rediscovered by later researchers. Such a study was that of **Stroop (1935)**, whose findings received little attention until the 1960s, when his work was finally recognised as a classic demonstration of some basic cognitive processes which had then begun to attract interest. Stroop's experiments had shown that it takes longer to name the ink colour of a word if that word is the name of a different colour (e.g., the word 'blue' written in red ink). Although this finding was largely disregarded at the time, later researchers would return to the

'Stroop effect' (as it became known) because it provided an excellent example of automatic processing (of the word meaning) as well as demonstrating interference between rival inputs. Today, the Stroop effect is used widely as a measure of both automaticity and interference, and consequently Stroop's paper has finally become a classic study after lying dormant for some 30 years. Stroop's study is discussed in Chapter 6.

Our understanding of memory and amnesia underwent a dramatic change with the publication of a paper by **Scoville and Milner (1957)** about a severely amnesic individual known as 'HM'. HM differed from patients studied previously in that his amnesia was caused by a surgical procedure performed on his temporal lobes. As a result, the date of onset of HM's amnesia was precisely known, as was the location of his brain lesions. William Scoville and Brenda Milner discovered that HM had been unable to create and store any new memories since surgery in 1953. However, his ability to retrieve memories from before this date seemed relatively unimpaired. Scoville and Milner therefore concluded that the main impairment suffered by HM was an inability to encode and store new memories, and showed this was associated with lesions in the medial temporal lobe, especially the hippocampus. Scoville and Milner also noted that HM's short-term memory remained unimpaired. Although subsequent research has revealed a rather more complex situation in studies of both HM and other amnesic patients, Scoville and Milner's paper remains a classic and a vital turning point in the study of amnesia. Their paper (and its impact on subsequent research) is discussed in Chapter 7.

Studies of amnesic patients like HM suggested that short-term memory and long-term memory involve quite separate mechanisms, though it was not entirely clear at that stage why there was a need for a separate memory system for storing memories over very short time periods. **Baddeley and Hitch (1974)** performed experiments suggesting that short-term memory actually operates as a mental workspace, which they called 'working memory'. Their study also provided evidence that working memory contains several different components, notably the central executive and memory loops whose function is to retain information very briefly to allow it to be processed. The working memory model proposed by Alan Baddeley and Graham Hitch is discussed and evaluated in Chapter 8.

A study by **Tulving (1972)** suggested that long-term memory could also be divided into sub-components, namely semantic memory (which stores knowledge and facts) and episodic memory (which stores memory for specific events). Endel Tulving demonstrated convincingly (and for the first time) that semantic and episodic memory exhibit different characteristics and have different processing requirements. However, the precise relationship between episodic and semantic memory is still not completely clear. In spite of their different characteristics, it is assumed they must overlap and interact to a considerable degree. Tulving's work on the distinction between episodic and semantic memory is discussed in Chapter 9.

Another important memory study was performed by **Tulving and Thomson (1973)**, who showed that successful retrieval of an episodic memory depends on the degree of match between the information in the retrieval cue and that in the stored trace. This became known as the Encoding Specificity Principle (ESP), and

it remains one of the most important theories of how memories are retrieved. ESP can provide an explanation for a number of well-established cognitive phenomena, such as transfer-appropriate processing and context-dependent memory. Tulving and Thomson's study is described in Chapter 10.

Another aspect of cognition involves the study of thinking and problem solving. **Newell, Shaw, and Simon (1958)** pioneered the use of computer simulation to test out theories of human problem solving. They argued that programs enabling a computer to solve problems by using a sequence of information-processing operations suggested possible models of human information-processing and problem solving. Newell et al.'s computer simulation approach was to become influential in many fields of cognitive psychology and is explained in Chapter 11.

Tversky and Kahneman (1974) investigated the strategies used by human beings when making judgements. They discovered people do not always make judgements rationally, as a computer might, but tend to make errors caused by a failure to consider all the relevant evidence. Tversky and Kahneman showed that when people make judgements they tend to apply well-tried strategies and heuristics which have apparently worked in the past, but which are actually prone to systematic biases. These findings have been enormously influential not only in the field of cognition but also in many other fields of psychology. Tversky and Kahneman's study and its subsequent influence is covered in Chapter 12.

In a later study, **Kahneman and Tversky (1979)** demonstrated further biases which occur when human beings make decisions. For example, when the probability of success is very low (e.g., when playing the National Lottery), people tend to be more risk-seeking over possible gains, but more risk-averse over possible losses. However, with high outcome probabilities this situation is reversed, and people tend to be more risk-seeking over possible losses. These findings formed the basis of Kahneman and Tversky's prospect theory, which has proved to be of great value not only to cognitive psychologists but also to economists making financial judgements. This work earned Kahneman the Nobel Prize for Economics in 2002, and it is discussed in Chapter 13.

The use of language is another important function which has interested cognitive psychologists, and the study of language impairment has proved to be particularly informative. **Chomsky (1957)** initiated a completely new approach to the study of language. Previous theories of language acquisition, based on the tenets of behaviourism, assumed that language was acquired by a process of reinforcement. Chomsky showed that reinforcement would be quite inadequate for the learning of complex grammar, and he argued that language acquisition depends upon an innate ability to generate speech and linguistic output from a set of grammatical rules. This theory was enormously influential, and it led to the founding of a new science of psycholinguistics. Chomsky's study is discussed in Chapter 14.

The study of language has also benefited greatly from research on language disorder, and one highly influential early study was that of **Marshall and Newcombe (1973)**. They studied a large number of cases of acquired dyslexia, and concluded that they did not all arise from the same cause. Marshall and

Newcombe realised there were several distinct subtypes of acquired dyslexia, and they constructed a model explaining each subtype as arising from impairments to different components of the model. This approach would subsequently be adopted by many other researchers, and it provided the basis of the new science of cognitive neuropsychology. Marshall and Newcombe's study is described in Chapter 15.

CLASSIC STUDIES: GENERAL LESSONS

There are obvious dangers in drawing general conclusions from the limited sample size (N = 14) of classic studies discussed in this book. However, we believe it is of interest to consider various factors often thought to be relevant to outstanding research.

Youthful creativity

Conventional wisdom has it that the most outstanding research (perhaps especially in the hard sciences) is produced by young researchers when creativity is maximal. Famous supporting evidence is provided by Albert Einstein's initial theory of relativity, produced when he was only 26 years old.

Jones and Weinberg (2011) discovered that youthful creativity has apparently become less important than it used to be. They focused on researchers in physics, chemistry, and medicine who won the Nobel Prize before 1905 or after 1985. In the earlier period, the mean ages at which these researchers produced their most outstanding research was 37, 40, and 45, respectively. In the later period, however, the mean ages were 50, 46, and 45, respectively. Thus, there has been a dramatic increase averaging over 8 years in the age at which outstanding research is produced.

Why has the age of outstanding scientific achievement increased? First, the age at which researchers obtain their highest degree has increased considerably. Jones and Weinberg (2011) found that the increased time researchers needed to acquire foundational knowledge predicted the age at which they produced their best research. Second, theorists had their greatest achievements 4.4 years earlier than empiricists, and the percentage of outstanding research that is theoretical has declined.

We turn belatedly to the ages at which cognitive psychologists produced their classic research. The mean age, based on all the authors of each study, was 40.4 years, a higher figure than many would have predicted. In fact, the figure increases to 41.6 years (which rounds up to 42) when we consider only the central researchers and not their co-authors.

During preparation of this chapter, we chanced upon a study by Franses (2014) on the age at which great artists since Goya produced their most outstanding paintings. By coincidence, the mean age was 42 years. Perhaps Douglas Adams (1979) was right when he claimed that 42 was 'the Answer to the Ultimate Question of Life, the Universe, and Everything'!

Most of our classic studies involved theoretical and empirical contributions and so we cannot neatly separate out theorists and empiricists. However, those whose contributions were primarily empirical were slightly younger than the mean age of the researchers as a whole. There was thus no support for Jones and Weinberg's (2011) findings for other scientific disciplines.

As discussed above, Jones and Weinberg (2011) found that the age at which researchers produced their best research had increased over time. We divided our sample into classic studies carried out in the 1950s or earlier (N = 5) and those from the 1970s or later (N = 9) (strangely, there were no studies from the 1960s). Contrary to Jones and Weinberg (2011), the mean age for the earlier period was approximately 1.4 years older.

Finally, we divided the classic studies into broad research areas (perception and attention; memory; language; and thinking and problem solving). The numbers in each category are very small. However, for what it is worth, memory researchers had the oldest mean age (44.2 years) and language researchers were the youngest (mean = 37.7 years).

Originality: First versus second movers

We might assume that outstanding research should be almost totally original. This is analogous to the notion of first-mover advantage in economics and marketing. Alternatively, we might assume that outstanding research often involves developing previous theoretical ideas, analogous to the notion of second-mover advantage. Note, however, the notion of 'originality' is somewhat subjective and there is no absolute distinction between first movers and second movers.

When we consider our classic studies, the studies from the 1950s and earlier tend to correspond more obviously to the notion of first mover than those from the 1970s onwards. We have five studies from the 1950s: Gibson (1950); Cherry (1953); Scoville and Milner (1957); Newell et al. (1958) and Chomsky (1957, 1959). In all cases, their studies owed relatively little to previous research or theorising. Gibson discovered the crucial importance of motion to visual perception, and Cherry discovered several of the key properties of selective auditory attention, a topic that had been almost ignored beforehand. Scoville and Milner found that the brain areas of key importance to long-term memory were much more circumscribed than previously believed. Newell et al. showed for the first time that computational modelling could be used to enhance our understanding of human problem solving. Chomsky showed that previous approaches to language (especially behaviourism) were woefully inadequate. He went on to provide an original and powerful theoretical analysis of the processes involved in language.

The situation is different with several studies from the 1970s and afterwards. Consider Tulving's (1972) classic study on the distinction between episodic and semantic memory. This distinction had been proposed by several psychologists and philosophers considerably earlier than 1972 (see Tulving, 1983). In our opinion, however, that does not detract from the importance of Tulving's contribution

because he was the first psychologist to develop the distinction and base a programme of experimental research on it.

Kahneman and Tversky's (1979) theoretical account of decision making under risk has deservedly been hugely influential. However, their prospect theory was based on the earlier expected utility theory and incorporated some of its assumptions. Their study is a classic because they eliminated most inadequacies of the previous theory and added powerful new theoretical assumptions.

Another example of a classic study built on a previous influential theory was the one by Goodale and Milner (1992). Mishkin, Ungerleider, and Macko (1983) put forward a theory in which they argued that object and spatial perception depend on separate cortical pathways. Goodale and Milner developed and extended this theory substantially and reported exciting new empirical findings.

Baddeley and Hitch's (1974) working memory model was much influenced by previous conceptualisations of short-term memory, especially that of Atkinson and Shiffrin (1968). However, their model represented a substantial development of earlier theories and involved the crucial insight that short-term memory plays an important role in numerous non-memory tasks (e.g., problem solving, language comprehension).

Overall, it is arguable that nine of our classic studies (Stroop, 1935; Gibson, 1950; Cherry, 1953; Chomsky, 1957, 1959; Scoville & Milner, 1957; Newell et al., 1958; Marshall & Newcombe, 1973; Tversky & Kahneman, 1974; Marr, 1982) illustrate first-mover advantage. In contrast, five classic studies (Tulving, 1972; Tulving & Thomson, 1973; Baddeley & Hitch, 1974; Kahneman & Tversky, 1979; Goodale & Milner, 1992) are examples of second-mover advantage. First-mover studies were published on average in 1960 whereas second-mover studies were published on average in 1978. This is unsurprising because the number of pre-existing influential theories that can be used as the basis for developing major new theories is almost bound to increase over time.

MAJOR APPROACHES

There are four major approaches to understanding human cognition (Groome, 2014; Eysenck & Keane, 2015). First, there is experimental cognitive psychology, which is the traditional approach based on conducting laboratory studies on healthy participants. Second, there is cognitive neuropsychology, which involves laboratory studies on brain-damaged individuals. Third, there is cognitive neuroscience, which involves obtaining measures of brain activity as well as behaviour under various task conditions. Fourth, there is computational cognitive science, which involves constructing computer models that mimick the behaviour of human participants.

It seems plausible to assume that much outstanding research would occur when researchers are among the first to use a given major approach in a particular research area. That is clearly one way in which new insights and original findings can be obtained.

The above notion is at least partially applicable to several of our classic studies. Three (Scoville & Milner, 1957; Marshall & Newcombe, 1973; Goodale & Milner, 1992) owe much of their classic status to findings obtained from one or more brain-damaged patients and thus fall within cognitive neuropsychology. Two others (Newell et al., 1958; Marr, 1982) were the first (or among the first) systematic attempts to develop systematic theoretical accounts in their respective research areas using computational modelling.

That leaves us with the dog that didn't bark in the night-time – cognitive neuroscience. In spite of the dramatic increase in research in cognitive neuroscience, we did not think any cognitive neuroscience studies deserved the status of classic. There are two likely explanations. First, cognitive neuroscience is a more recent approach than the others, having only been used extensively since the 1990s, and it may simply take longer for classic studies in cognitive neuroscience to emerge. Second, although cognitive neuroscience has proved increasingly important in testing pre-existing theories, it has as yet led to the development of very few new theories. This is probably the case because (unlike cognitive neuropsychology), cognitive neuroscience has rarely produced surprising and dramatic findings.

Falsification, generality, and granularity

Philosophers of science have long argued about the nature of scientific progress (Okasha, 2002). Karl Popper argued that a scientific theory should be falsifiable, that is, it should make definite predictions that can (at least in principle) be shown to be incorrect. This leads to the notion that theories should be rejected when falsifying evidence is obtained.

Theorists agreeing with Popper would presumably develop relatively specific or narrow theories low in granularity or detail. The reason is that such theories would typically be harder to falsify than more ambitious theories.

Popper is correct in arguing that we would have little confidence in a theory whose predictions were consistently falsified. However, Popper's approach is oversimplified. Lakatos (2001) proposed a preferable approach. According to him, every great scientific theory is immediately engulfed in an 'ocean of anomalies' (p. 172). Thus, virtually all theories have been falsified. What, then, determines which theories should be retained? According to Lakatos, two factors are crucial. First, most theorists add auxiliary hypotheses to address problems within their theory. With theories that should be retained, these auxiliary hypotheses are progressive or productive, that is, they enhance the theory's predictive power. Sadly, it often takes a long time before it is clear whether a theory is progressive or degenerative. Second, theories should be retained until they are superseded by a superior theory.

What light do our classic studies shed on the above issues? First, most of the theories contained in these studies were known to be false at the time they were proposed, which is much more in line with Lakatos than Popper. For example, it was always improbable that all of visual perception can be understood in terms of two independent visual processing systems (Goodale & Milner). Another example is Baddeley and Hitch's working memory model. Active haptic and kinaesthetic

processing can occur within working memory, but both forms of processing were omitted (and continue to be omitted) from their model.

Second, there is the issue of generality. It is often argued that cognitive psychology is plagued by paradigm specificity (e.g., Meiser, 2011), meaning empirical research and theorising are excessively focused on specific paradigms or experimental tasks. Consider research on visual search. The typical paradigm requires participants to detect a target stimulus presented at a *random* location within a visual display containing several distractors. Excessive use of this paradigm led theorists to ignore completely the most important determinant of target-detect time – the *predictability* of the visual environment. If you are looking for a pedestrian in a street scene, he/she is far more likely to be located on the pavement or street than halfway up a building or in the sky (Ehinger, Hidalgo-Sotelo, Torraiba, & Oliva, 2009).

In spite of the above example, several of our classic studies contain very general theories. For example, Marr (1982) identified the key processes involved in object recognition, Tulving and Thomson (1973) indicated how retrieval from long-term memory occurs, Baddeley and Hitch (1974) proposed a comprehensive theory of short-term memory, Kahneman and Tversky (1979) theorised about risky decision making, Goodale and Milner (1992) proposed an ambitious theory about visual perception, and Chomsky (1957, 1959) provided an overarching theory of language.

Third, there is the issue of granularity or level of detail. It is often assumed (especially by computational cognitive scientists) that theories in cognitive psychology should be fully explicit and detailed in their assumptions and predictions. In fact, that is often an unnecessarily stringent requirement because it makes theories excessively susceptible to falsification. For example, Baddeley and Hitch in their working memory model were deliberately vague about the precise nature of the central executive, which remains the case to a lesser extent 40 years later. Tversky and Kahneman (1974) identified several important heuristics and biases but did not spell out precisely when each one would be in use. Goodale and Milner (1992) did not specify all the characteristics of their two visual processing systems or the details of their interactions, and Tulving (1972) did not identify all the differences between episodic and semantic memory or how they interact.

In sum, at the risk of oversimplification, the most successful theories are those that are *productive* (i.e., leading to much important research) rather than those that have avoided *falsification*. Successful theories also tend to be general in scope and not especially granular.

CONCLUSIONS

We conclude with two final thoughts. First, as you may have been thinking, we probably should have referred earlier to the 'great person' hypothesis – the notion that outstanding research depends on individual genius rather than the context in which research is conducted. The a priori probability was extremely low that one psychologist (Tulving) would account for two of the 14 classic studies and that a team of two psychologists (Kahneman and Tversky) would account for two more.

Finally, of the 20 different names among the authors of the 14 classic studies, only two (Brenda Milner and Freda Newcombe) are female. All the evidence suggests that there would be a much higher proportion of female researchers in a future edition of *Classic studies in cognitive psychology* in, say, 2030. That is our prediction (and hope).

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