Module: Psychological Foundations of Mental Health

Week 1
Introduction to cognitive psychology

Topic 3
The cognitive (r)evolution – Part 2 of 3

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Lecture transcript

Slide 2
The previous discussion of Tolman's models brings us now to consider what it is that makes cognitive psychology distinct from what preceded it. We will briefly consider what might be considered the building blocks of cognitive psychology, the elements that make up the range of empirically testable models that cognitive psychology uses to try to understand, explain, and predict behaviour in the broadest sense.

Slide 3
We learned at the start of this module that cognitive psychology is fundamentally concerned with scientific inquiry into, first, the mental structures that represent information and knowledge, and second, how this knowledge is processed and transformed to enable adaptive behaviour. By definition, then, cognitive psychology is concerned with unobservable entities.

The early introspectionists attempted to uncover some of these, while behaviourism strongly sought to minimise and ignore them. This difference in scientific philosophy between behaviourism and cognitivism can be seen in how the contents of the black box is labelled. While the behaviourists and neo-behaviorists chose to label the contents "intervening variables," cognitive psychology has chosen the label "hypothetical constructs."

This choice of label is more than just semantic. By labelling an unobservable entity a construct and a hypothetical one at that, there is an explicit acknowledgement that we do not know for sure whether that entity exists and functions in the way proposed. However, the approach taken by cognitive psychology is that we can propose reasonable theoretical models based on evidence and, critically, models that are testable empirically by further experiments

This ability in cognitive psychology to make testable predictions of its hypothetical constructs is sometimes called their surplus meaning. This describes the fact that we can not only use induction to posit the constructs' existence, but we can also use scientific deduction to hypothesise and reveal new knowledge through experiments. These, in turn, may suggest new theories and models.

One of the criticisms of behaviourism is that its models lacked this surplus meaning, that by the middle of the 20th century, they had to be continuously adapted and made more complex to fit the accumulating data, rather than providing new directions of study to unexplored areas.

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A useful discussion of the nature and value of surplus meaning can be found in John Greenwood's 1999 paper, "Understanding the Cognitive Revolution in Psychology." In this paper, he notes that surplus meaning in science is essential to the development of the theory and knowledge, provided that surplus meaning is open to empirical scrutiny that either supports or refutes it. However, where a theory has no surplus meaning, it becomes closed and sterile.

Slide 4

What are the hypothetical constructs or building blocks on which cognitive psychology models are based? This slide offers a non-exhaustive list of some of the building blocks that you will learn about in this and in later modules, especially as we apply them to the area of mental health. First, though, let's remind ourselves of the scope of cognitive psychology, the so-called domains of cognition, for which theories are developed and tested. These have changed little over the course of evolution of psychology and would have been recognisable to Aristotle and Plato.

We have heard how previous psychological approaches, including introspection and behaviourism, focused on a limited set of these domains, those that were felt either to be amenable to study within the techniques available or necessary for the explanation of behaviour. A crucial feature of cognitive psychology is that it seeks to encompass them all within an overarching framework and set of empirical methods, from perception to action. It covers not just learning, but language and problem solving and reasoning and many others.

Cognitive psychology has also broadened its scope as the discipline has involved, including areas such as emotion and social cognition not listed here. Some areas are crucial to our understanding of mental health, along with other, more traditional areas.

Cognitive psychology is based on the presumed existence of cognitive structures and cognitive processes that serve the functions of these domains. Structures here refers to conceptually coherent, modular units that serve a particular function within one or more domains of cognition. A structure typically refers to an internal form or representation of information. A number of examples are shown here.

You will recall that Wundt was almost exclusively concerned with the study of the mental image, the internal structure or visual representation of an object or a scene, although images can also involve other senses, auditory, olfactory, and tactile. Other structures that cognitive psychology considers are more abstract than the seemingly sensory-like properties of an image. These include symbolic representations of knowledge, such as the sounds attached to written letters or the meaning attached to whole words.

Concepts are another type of cognitive structure, such as size or attractiveness. Others include rules, also known as heuristics, both conscious and unconscious, which govern relationships between knowledge and guide our behaviour. We can also consider beliefs and interpretations that we hold about the meaning of the world about us, representations that we will be returning to later in this module.

The representations of information that constitute these cognitive structures are not static. Instead, they are subject to change by a range of cognitive processes or operations that can be applied to the information and often transform it. For example, the process may associate two pieces of information or discriminate between them. Information may be compared and categorised based on similarity.

We may bring to bear prior knowledge and beliefs to evaluate the significance of information in our world to guide our actions. We encode all information coming to us from our senses, transforming it in many ways before it is stored as a memory and potentially accessible to be retrieved and used. We'll be covering many of these domains, structures, and processes in later weeks in this module.

Slide 5

It's important to note that cognitive psychology does not concern itself directly with how hypothetical constructs exist or function physically within the brain. Indeed, it is possible to ignore the brain altogether, although obviously not denying that it exists. Basically, there is no need to assume that a particular cognitive structure or process has an equivalent physical representation within the brain structure or system.

Obviously, the brain can be considered as the organ of the mind, so there are critical scientific questions that bring together cognitive theory and knowledge with brain biology. As we saw, with the mental maps and navigation, evidence in animal studies, human cognitive psychology, and neuroscience come into play and converge. The surplus meaning of cognitive models of navigation and mental maps stimulated brain science to investigate their potential biological basis.

When this happens and evidence aligns, it gives us much greater confidence that our models and theories are correct and that the hypothetical constructs we are working with have validity. This area, cognitive neuroscience, is one of the fastest growing areas of cognitive science today and will be an important strand through much of this module and others.

However, leaving brain neuroscience for now, let's look at a few examples of hypothetical constructs from a purely cognitive perspective-- structures and processes that have emerged from the two-way interaction between cognitive theory and empirical research.

Slide 6

For the rest of this topic, I want to introduce just a few examples of how cognitive psychology has addressed the task of understanding the structures and processes of the mind by using empirical methods to uncover new surplus meaning from hypothetical constructs. The examples chosen are from classical studies, all dating from the 1970s, when cognitive psychology was exploding as a discipline.

As such, they do not represent cutting-edge science. In most cases, the models that they used and tested have been replaced over the decades that follow. What is more important here is to illustrate how cognitive psychological methods and theories can take us far beyond early cognitivist approaches and can overcome the behaviourist objection to the unobservable.

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This first example addresses a simple question. If we are presented with an item of information and asked to decide whether we have recently seen it before, how do we do it? Can we understand the way in which the information is stored and processed to perform the decision task?

This classical experiment was published in 1966 by Saul Sternburg. He opened the paper by posing the question, how is symbolic information retrieved from memory? Sternburg focused on the retrieval of information presented just seconds before, so-called short-term memory, not information presented and stored minutes, hours, days, or months before, like Ebbinghaus.

The symbolic information that Sternberg used was written numbers. These have no inherent meaning, but we learn that the symbol was used to convey meaning, in this case, about quantity. However, the nature of the symbolic information is not the critical thing about this study.

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This figure gives a schematic representation of the task, showing items displayed as presented in the sequence over time from bottom-left to top-right. This way of displaying cognitive tasks is commonly used, and you will see it on many occasions over the course of this programme. The basic task involves presenting a short sequence of numbers-- today, it would be on a computer screen-- individually in the centre of the screen, for just over one second each.

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Each sequence was between one and six digits long. And each number appeared only once in a sequence. We show here a trial with just four digits in the sequence. Sequences of up to six items are readily held in our memory for a short period of time and can be repeated back accurately if done immediately. The limit to doing this accurately is called our immediate memory span.

At the end of the sequence, after two seconds, there was an auditory warning signal and then the presentation of another number, the test digit. The research subjects' task was simply to decide whether that number was present in the list that they have just seen and to indicate their decision by pulling a lever to indicate yes or no.

The critical measure was the time taken to make the correct response, their reaction time. This reaction time and variation in it can give us clues about the cognitive operations at work. The experiment systematically varied not just the length of the original sequence, but where in the sequence the target number occurred, in positions one or two or three and so on, and made sure that the target was equally distributed over the different positions across all of the trials.

The main empirical question being addressed was, what is the effect of the length of the list on the time taken to make an accurate decision? The results were clear cut. The longer the list length, the longer the mean or average reaction time.

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Let's look a little more closely at this seemingly simple task and what is happening in cognitive terms when performing it. First, we might compare the test and study numbers item by item, until we find a match, so-called serial search. Alternatively, we might be able to compare the test item with the whole set, all at once in our memory, so-called parallel search.

The two methods, however, lead to very different predictions from the data. The serial search strategy would predict that the response time increases in a consistent, linear fashion the more items there are in the list, at least for the range of list lengths used in the study. A parallel search strategy would predict that the response time is the same regardless of the number of items in the list.

The results were clear cut and have been replicated many times. This graph of some of the real data shows the mean reaction time for a group of subjects over multiple trials for the list lengths of one to six. The solid line is the regression line, which shows the relationship between the two for the positive responses, where the test item was present in the set.

As we see, there is a very strong, linear relationship between reaction time and list length. This favours the serial search model. What is more, the data suggests, for this experiment, at least, that the scanning and comparison of items in memory took just 40 milliseconds for each item.

The dotted line on the graph shows the data for the negative sets, where the test item was not present in the study list. Although they look somewhat different, the slopes of the two lines were not significantly different.

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With a serial search process, it follows that if the test item was not in the study list, the search would have to go through all of the items before a decision could be made that the item was not present. However, what if the item was present? What is the effect of the position of the item in the study list?

If the search stops as soon as the item is detected, the reaction time will be shorter for items presented early in the list than for later, independent of the length of the list. This is called a self-terminating search.

However, if the search continues to the end, regardless of the position of the item, the time to

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detect whether an item was present will be the same as the time taken to detect that it was absent. Practically, what we would expect to see across all trials is that the slope of the line for a self-terminating search for positive items would be half of that for the negative items that needed exhaustive search.

In fact, as we see in the actual data, the slopes of the two lines were very similar, the seeming difference in their shapes are not significant. And the solid line is certainly not half the slope of the dotted line. This supports the hypothesis that search is exhaustive. In other words, it continues even when a match has been made.

You don't need to remember the details of this experiment. What is important is taking away the idea of how a relatively simple experiment can allow us to gain some deep insights into a range of cognitive processes involved. It tells us, for this type of material, with short lists held briefly in memory, that when we access our memory to make decisions, we do so using serial, exhaustive processes.

Equally importantly, it shows us that we can reliably gain access to and study our internal processes empirically, something that Kant rejected, the introspectionists tried to do, but with severe constraints, and which the behaviourists said we should avoid at all costs.

Slide 11
Let's look at another example, again, one where we can study and gain insights into the nature of an internal representation and how it is processed, the essence of cognitive psychology. This classic experiment addresses a topic that was dear to the heart of Weber and the structuralist school, the mental image.

This study by Shepard and Metzler shares many features with the Sternberg study and, indeed, with many experiments in cognitive psychology. It relies on reaction times to make relatively simple decisions, while systematically manipulating one element of the task repeatedly over many trials and across many research subjects, the method of mental chronometry, first pioneered by Weber, but now applied much more carefully.

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The material used by Shepard and Metzler was drawings of non-meaningful, three-dimensional objects, like these two examples. The basic task involved presenting a pair of objects and asking the subject to react as quickly as possible to say whether they were the same or different. However, they had to judge whether the two objects were the same if one of them could be rotated in any direction or physical plane to match the other.

This matching task was therefore more than comparing what could be seen, the input, but matching based on an internal process, a hypothetical construct here labelled mental rotation, to permit an output, a decision, and a response. On the right, we see three examples from the original paper. The top two can be matched. The bottom one cannot, however much we try to rotate in any direction or plane.

Pairs of images in the study were rotated either in the flat plane of the picture, the so-called picture plane, or in the perpendicular plane, into or out of the picture, the depth plane. The practical question being asked was, what is the relationship between the time to make a correct positive match and the difference in angle of rotation between the two items?

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We can hypothesise a set of processes at work that first construct a mental representation of object A and object B, and then compare them in a way that permits a similarity judgement to be made. One hypothesis is that their similarity is evident regardless of the angle through which they are rotated.

If this is the case, then the time to make a correct match would be the same for all angles of difference. However, if there is a serial process, then there would be a systematic relationship between the angle and the reaction time. This is what we find.

We see here, at the top, the mean reaction time for same matches for rotations in the picture plane. We see a clear and systematic linear relationship between the angle and the response time to make the match, with 10 degrees of rotation adding about 300 milliseconds to the decision time, almost exactly the same results as seen when the rotation is in the depth plane. Indeed, the same is seen for two-dimensional random shapes, so it is not dependent on the spatial complexity.

Such data tell us that we can access internal visual-spatial representations of objects and transform them in a way to enable judgments and decisions to be made. What is intriguing is that the manipulation happens at a particular, measurable, but quite slow speed, analogous to manipulating a real 3D object in our hand.

Obviously, there is no real object. This is an abstract, internal representation. However, the evidence suggests that its spatial properties follow principles similar to that seen in the real world, in other words, that Euclidean properties, such as relative angle, may be coded within the brain and accessible to manipulation.

This hypothesis was a subject of hot debate within cognitive psychology for many years, whether the coding was indeed spatial or what was called propositional, such as above versus below, to the left, or to the right. Although not fully settled, the evidence does seem to support the existence of spatially encoded information within the brain, something that lends credibility to the concept of mental maps.

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This last example of a classic experiment is from the domain of memory. Unlike the type of memory studied in the memory scanning task, this is the more familiar type of memory, where we learn information and try to remember it minutes, hours, or days later, just as Ebbinghaus did in his study. You will remember that Ebbinghaus deliberately used meaningless material for his experiments.

However, in real life, information that we want to learn, retain, and later recall has meaning and conveys real information. Revising for exams is a good real life example of such learning and long-term memory. Does how we learn influence how much we remember at a later time?

We all have access to our own experience in this. A quick read of an article or lecture notes is unlikely to lead to the same degree of retention as a deep read with note taking, mind maps, and other study tools. Why should this be the case? Is it just the amount of time we spend on the learning? Or how we process the information at that time?

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This question was tackled in a classic experiment by Fergus Craik and Endel Tulving in 1975. They argued that all information, whether words or sounds or pictures, could be represented in different ways. Some are rather superficial, unrelated to their physical form. However, written words are more than just a collection of lines or even letters that convey knowledge and meaning.

This represents at least two different levels or depth of representation. For example, when we are presented with a word, we may process or store both its physical form, what it looks like, the sound it makes when spoken, or aspects relating to its meaning. Depending on how we go about the task of learning in the first place, what is the effects of the depth of initial processing of the information on subsequent recall?

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In a standard learning and memory experiment, a participant is presented with a list of items, such as words, on one or more occasions and typically asked to remember them for later recall. After a

delay, their ability to repeat them accurately is measured. The amount remembered is assumed to reflect the efficiency of their memory. Craik and Tulving hypothesised that the deeper the processing, the better the subsequent retrieval.

In their experiment, information, in the form of words, was presented to research participants with various task instructions. Note, they were not told that they had to learn or remember the words. 60 words were briefly presented, one at a time. And for each, the subject was asked to answer one of three questions as quickly as possible.

The first question required only that they attended to a physical feature of the printed word, its case, whether upper or lower. This was seen as the lowest depth of processing and would be associated with the poorest subsequent retrieval.

The second question required them to process the sound of the word when it was pronounced, its phonemic features, a more complex level of processing that would, it was predicted, lead to better retention. The question was whether the word rhymed with another shown.

Finally, the third question, they were asked about the meaning of the word, its semantic content, the most detailed or elaborated level of processing, and the one that should lead to the greatest retention. The question here was whether the item made sense within a sentence shown.

Memory was tested immediately afterwards, by presenting the 60 words seen before with 120 new words and asked which they recognised.

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Here are the main results from the study, which support the depth of processing hypothesis. First, on the left, we see that it took longer to answer the sentence question, then the rhyme question, then the case question. This suggests more elaborated processes were involved.

Second, on the right, we see that accuracy, the percentage correctly recognised, went from less than 20% for the case question, with its superficial processing, to around 80% for the sentence question, where the person had to consider the words' meaning.

Specific aspects of the depth of processing model have been disputed over the years, particularly in terms of precisely what cognitive mechanisms are operating. However, the study supports an important general point. The more we think about and elaborate in our minds a piece of information, the more likely it is that it will be accessible later for recall.

This has obvious implications for how we revise for exams. Simply reading is less effective than using the material or elaborating and representing it in new ways, in other words, thinking about and using the information.

However, there are also potential disadvantages of a deep level of processing. Throughout our day, things are happening to us, most of which we ignore at the time or forget soon after. However, sometimes, things happen which we then think about deeply, looking for meaning and elaborating. When the thing that happened was an embarrassing incident, doing badly in a job interview or an argument with a friend, it seems likely that the more we process that information, the clearer and stronger the memory will be.

This is just what we see in people with depression and anxiety. There is a tendency to dwell on negative things or rehearse them in our mind, trying to work out why they happened or what we could have done differently. It's not surprising, therefore, that such negative memories tend to be stronger in people with depression and anxiety, something called a memory bias, with important implications for the maintenance of their problems. The depth of processing explanation is one of a number of factors that may contribute to this memory bias in depression.

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