Notes for

02454 Introduction to Cognitive Science

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What is cognitive psychology?

Cognitive psychology is concerned with how people remember, pay attention and think. What we do, think and feel is biased by things we already know.

Introspection is the examination of one's own conscious thoughts and feelings. Quickly died off as it cannot inform us about the unconscious mental events of the body.

The behaviourist movement rejected introspection and insisted that psychology should only concern mechanisms that were objective and observable. However, evidence suggests that our behaviour is often shaped by our perception, i.e. our mental state.

Cognitive psychology emerged as a discipline in the late 1950s, as a result of above failed movements. Focuses on the study of both conscious and unconscious mental events by observing and modelling the human body. Objective, observable "black-box testing" of the mind.

Capgras syndrome and H.M.

Capgras syndrome: reverse Alzheimer's. Patient recognises family and friends but is convinced that they are not who they claim to be – e.g. they are a robot clone. Patients insist that there are subtle (non-existent) differences.

Brain structure and lesions (damage to the brain) can be examined by neuro-imaging.

Damage to **frontal lobe** makes it difficult to distinguish between real and not real, like patients suffering from schizophrenia. Damage to the **amygdala** removes the sense of familiarity.

Amygdala and hippocampus responsible for emotional processing and learning/memory, respectively.

Infamous patient H.M. had a special kind of amnesia in which he could not remember any event after the surgery in which he had his hippocampus removed.

Patients suffering from Korsakoff's amnesia (like H.M., unable to retain new memories) only seem to have their **explicit memory** impaired, but still improve on indirect memory testing (i.e. priming).

The eye

There are two types of photoreceptors in the eye:

Rods that are colour-blind and sensitive to low levels of light (helps us see in darkness)

Cones that are less sensitive and thus need more incoming light to function at all. We have three kinds of cones that are sensitive to three different wavelengths, i.e. colours.
Cones can also see fine details, allowing us to focus on objects.

Lateral inhibition is a visual effect in which cells inhibit some of the action from neighbouring cells. As a result, cells near an edge (between activated and not activated cells) are more strongly activated than other cells with the same level of activation.
On the other hand, cells on the dark side of an edge also inhibit from its bright neighbour, resulting in a perceptually darker cell.

For an image with a bright patch to the left and a dark patch to the right, the activation level of cells may look like below:

$$\mathrm{A} = [0.9\ 0.8\ 0.8\ 0.8\ 0.9\ \text{-}0.1\ 0\ 0\ 0\ 0]$$

Receptive fields describe what kind of stimuli a neuron/cell of the visual system responds to. It might be that a neuron is a "dot detector" and reaches its maximum firing when it sees a dot. If the dot is displaced and located outside the center of the receptive field, however, the neuron might even fire *less* than its resting state. Such a cell is called a **center-surround cell**.
Other receptive fields include edges and some cells might even be receptive only to movement in a specific direction.

The brain processes visual input in parallel and in a loop. As such, the brain can process e.g. colours or movement independently, and higher-level processing can affect low-level processes.

The visual system has two main pathways: the **what** and **where** pathways. Information from the primary visual cortex (V1) is transmitted to both systems and they work in parallel. Patients with damage to the *what* pathway have issues identifying even simple objects, but can grab them just fine. Reversely, patients with damage to the *where* pathway can identify objects perfectly, but fail to identify the position of the object and thus have difficulties picking up items in front of them.

Visual perception

Our perception of objects goes "beyond the information given" in the sense that we perceive more than the sum of visual inputs itself. One example is the Necker cube, in which it can be interpreted in two different ways, depending on the perception of the observer.

One might expect that humans first collect visual input and then proceed to interpret that input. This is however **wrong**. Evidence shows that we first organize the input, then collect appropriate features and interpret them. An example is when there is a "hidden" message in an image; we do not recognize it immediately, but after a short while it is reorganized, and we then discover the features.

We also have no difficulties reading messages that are distorted or missing some features; our brain thus "fills in" the gaps automatically for us – an example of perceptual bias.

Familiarity occurs when we *perceive* something as similar, not when it *is* similar.

Object recognition – in broad terms

We have a feature-based perception of objects, which has several benefits. Firstly, the detection of simple shapes such as lines or circles can have many purposes, and it allows us to recognize objects even though they are in different shapes, positions, views or lighting (or even just partly visible).

When tasked to locate a line in between a number of circles, the number of circles present has little influence to speed; detecting the presence of simple features is thus very fast. Same pattern is seen for detection of colour, orientation and many other simple features.

Patients with **integrative agnosia** appear normal when tasked to detect simple features, but it is difficult for them to judge how features are bound together to form complex objects. As such, detection of simple features can be considered a first step of processing.

Word recognition

When subjects are shown a word for a brief moment (e.g. 20 ms), they are usually able to recognize familiar words, but struggle to recognize rare words. When a subject is shown a rare word and then views it again a little later, however, they are much more likely to recognize it – **repetition priming**.

The **word-superiority effect** is the fact that words are easier to perceive than isolated letters. Subjects are better at determining whether a given letter is present for a brief moment if it is part of a word (e.g. DARK) as compared to a single letter (e.g. E), despite 50/50 chance in either scenario.

Degree of well-formedness is the measure of context when detecting letters within a word. It is easier to detect an E in the word CASE than in FIKE (non-existent word), and even more so than e.g. HGFE. Therefore, whether a word adheres to the rules of a familiar language influences our ability to recognize individual letters within that word.

Over-regularization is the concept of correcting words that are unfamiliar to us to more common words. For example, TPUM is likely perceived as TRUM or even DRUM, which shows a bias.

Feature nets

A network consisting of multiple layers, in which the subsequent layers detect more complex features or objects than the previous. Detectors fire when they are above some threshold, and the starting threshold of a detector may be individual and they thus require different levels of activation to fire.

Depending on how recently and often a detector fires, it will be easier to fire again. These two effects are called the **warm-up** effect and the **exercise** effect.

For word detection, one may consider a layer of bi-grams or even tri-grams. Frequently seen x-grams are more likely to fire and our brain might sometimes thus over-regularize on rarely seen x-grams as they need a higher level of activation.

The network is designed for *efficiency* and will thus sometimes make regularization errors.

In a feature net, information flows only in **one direction**.

Descendant of the feature net

The **McClelland and Rumelhart model** is similar to the feature net but does not have bi-gram detectors. Instead, they propose that detection of a letter "excites" a word, and that letters as well as words may inhibit from each other. As such, if the net is presented with a word TRIP, the letter detectors are activated and excite the TRIP detector, while e.g. the letter detector for G and the word detector for TRAP are inhibited and thus receive less activation. In such a model, inhibition is meant to decrease the likeliness of activating the wrong words.

In the McClelland and Rumelhart model, information flows **up, down and sideways**, such that all detectors (whether they are letter detectors or word detectors) can influence each other.
This model explains the effect that higher-level detectors have on lower-level detectors (perception) and may thus be preferred over the simple feature net.

Recognition by components (RBC)

Hummel and Biederman proposes a recognition by components model, which is a network that aims to explain how we recognize objects by an intermediate level of detectors sensitive to **geons**. Geons are the basic building blocks of all objects and are essentially simple shapes such as cylinder, cones and blocks.

In the RBC model, the lowest level of detectors are feature detectors corresponding to edges, curves, vertices and so on. These detectors in turn activate the geon detectors. After that layer comes several layers that aim to combine geons, and the theory is that all objects in the world are represented by a number of combined geons. At the top of the layers, there is a *object model* layer in which the final representation of the object can be activated.
This model works particularly well for **viewpoint-independent** recognition. No matter how a cat is positioned, we still recognize it as a cat due to its geon-based representation.

Recognition via multiple views

Some researchers propose a different approach for object recognition. They suggest that, when we observe e.g. a cat from different perspectives, each perspective is stored in memory. There is, however, a limitation to how many perspectives can be stored in memory, and recognition thus takes longer for such perspectives as the brain has to "rotate" the cat to match it in memory. Therefore, this model suggests that recognition is **view-dependent**, which is also backed by studies.

It is likely that low-level detectors detect features etc. and the high-level representation of the object is then mapped view-dependently to memory for recognition. If the object is detected from a common view, it is more easily detected.

Face recognition

Evidence suggests that we might have separate systems for more specialised recognition. For example, humans can easily recognize faces that are upside-down, distorted or otherwise manipulated compared to e.g. a house. Patients with **prosopagnosia** fail to recognize faces but may also fail to recognize e.g. their own car in parking lot. As such, specialised recognition might apply to more than just faces. This group of recognition systems are called **configuration detection systems**.

Selective listening

Shadowing is a task in which participants hear a tape of someone speaking and must echo this speech back word for word, while they are listening to it. Typically, such experiments have an attended channel and an unattended channel. This overall setup is called **dichotic listening**.

Under such circumstances, participants can perfectly shadow one channel while hearing remarkably little from the unattended channel. Participants cannot tell if the unattended channel contained coherent sentences or random words.
A similar observation is made on visual inputs. If presented with a video containing a primary event and some obscure activity in the background, few observers see what is going on the background.

In selective listening experiments, however, participants were typically able to recall if it was human speech, music or silence in the unattended channel. They could also report whether the speaker was male or female and if they were speaking loudly or softly.

If a person's name or something similar is mentioned in the unattended channel, the participant is likely to recognize it. This effect is often referred to as the **cocktail party effect**.

Perceiving and limits on cognitive capacity

In broad terms, there are two ways to think of attention:

Early selection hypothesises that the attended input is identified and privileged from the start (and the unattended input thus receives little processing).

Late selection hypothesises that all inputs receive a relatively complete analysis, but only the attended input reaches consciousness and/or is remembered.

Both selections seem to play a role. In some cases, people seem genuinely unaware of distractors, but are influenced by them anyway (late selection). In other cases, people receive stimuli from distractors, but they are falling out of the stream of processing early on and thus receive little analysis (early selection).
Whether the brain uses early selection or late selection depends on the type of input. For complex inputs requiring a lot of processing, little processing power is left for other inputs (early selection). For simple inputs, more processing power is free to work on other inputs (late selection).

Priming attention: Posner and Snyder's experiment tests whether priming a letter increases the response time for assessing whether that letter is shown a second time or not, e.g. priming A and then showing A A – participant has to assess whether the two letters are the same or not.
Conclusion: Reliable (high-validity) priming increases performance if correct and decreases performance if it is misleading (i.e. showing a different letter than expected). In low-validity condition the priming still increased performance, but misleading prime did not hurt response time.

Attention to objects vs. position: evidence shows that we in some cases pay attention to an object, and in some cases pay attention to a position.
For example, patients with **unilateral neglect syndrome** will eat food from only one side of their plate and only see objects on one side of vision.
However, when observing an object that moves from their healthy side to their neglected side of vision, the patient still observes it correctly (so attention is now object-based). Therefore, a mixture of the two attentional models is needed.

Divided attention

The brain has a limited number of resources for specialized tasks such as verbal or visual tasks. As some resources are task-specific, some tasks will be easier to do simultaneously than others.

Measured by difficulty, a few tasks requiring divided attention is listed:
listen + listen = most difficult, listen + read = less difficult, listen + see pictures = the easiest.

However, even tasks that seemingly have no connection still compete for resources. This is due to the need for **general resources**. Some researchers suggest that the general resources act as an operating system, in which it manages other tasks.
This would explain why multi-tasking is possible, but slower and less efficient than simply performing each task sequentially, as there is some overhead in switching back and forth between active tasks being processed. This also results in slower reaction times for either task – e.g. driving while on the phone results in slower responses while driving.

Our **executive control** is responsible for planning, setting goals and in general directs the function of cognitive processes. When we must behave in new environments or new tasks, we cannot follow habit; we need to set goals and strategies.
Researchers suggest that the executive control is responsible for this. Therefore, it can be considered a **task-general** resource. People with a larger working memory capacity (WMC) tend to have a better executive control and can better resist distractions and habit or reflexes.

Patients with damage to the prefrontal cortex often show a "goal neglect", which is directly related to the executive control.

Practice: when two tasks are simple, it is very easy to do both – e.g. driving and being on the phone. As soon as the driving becomes more challenging or the conversation gets more complex, one shifts all attention to the difficult part.
When a task is *practiced*, it becomes easier to perform and we can more easily do other things simultaneously. This is because practiced tasks only have a small demand for the executive control.

Once a task has been practiced enough, it can be performed automatically – such tasks are referred to as **automatic tasks** and require no executive control.

Acquisition of memory (learning)

Information is processed in discrete steps one-by-one. Such model is called a **modal model**.

All mental tasks rely on the working memory, which is equivalent to **short-term memory**. Working memory is used to store information currently in use and is not remembered afterwards.
Long-term memory contains information about previous experiences and knowledge, and it is what we consider *memories*. Research demands a distinction between these two memories.

Consider an experiment where participants read a list of words and are told to repeat back as many words as possible after they have finished reading the list. They are free to report words in any order they want, and the test is thus called a **free recall** test.
People usually remember 12-15 words and are extremely likely to remember the first few words – known as the **primacy effect** – as well as the last few words – the **recency effect**.
Participants were slightly better at recalling the beginning of the sequence than the end.

Primacy effect: as only a few words are placed in working memory to begin with, these words are ran through the rehearsal loop and are thus more easily remembered.
Recency effect: as the last few words are still placed in working memory, it is easy to recall them.

Working memory

The working memory consists of a central executive, a phonological buffer and memory "slots". When trying to keep information in working memory, one can utilise the *rehearsal loop* (repeating the information over and over using an "inner voice"). If a subject is speaking, e.g. saying tah-tah-tah while trying to rehearse a list of words, their performance is drastically decreased, which suggests that the rehearsal loop is important to our short-term memory.

The capacity of working memory depends on the individual.
Studies show positive correlation between working memory capacity and efficiency in reading, reasoning, following directions and performance on written exams.

In a digit-span task participants are to read a sequence of digits and repeat them back afterwards. If they do it successfully, they are given a longer sequence and this is repeated until they fail.
Typically, participants fail at 7 ± 2 digits, which suggests a working capacity of 7 items on average.

Items can be considered *chunks* of information. If one is able to chunk their items effectively, the working memory can hold a lot of information. An example is the combination of letters into words or even phrases that can be stored as a single chunk in working memory.

The digit-span task is a very traditional and static analysis of working memory. To better represent real-life scenarios, one should consider tasks that test the **operation-span** – e.g. math problems.

Evidence suggests that working memory is more like a system than just storage of information.
For tasks that need planning, the central executive is the one doing the real "work" although content is stored in working memory. For simple tasks, however, the working memory is mostly for storage.

One proposal is that the central executive of the working memory *is* the same as the executive control (task-general resources), which is supported by evidence. Patients with damage to the frontal lobe (used for working memory) also suffer from goal neglect, and it is thus likely that the central executive is the executive control.

Long-term memory

When we are trying to remember something, we often rehearse it. There are two types of rehearsal: **Maintenance rehearsal** in which we simply focus on the to-be-remembered items without thinking about meaning or relation, and **relational**, or **elaborative rehearsal** which involves thinking about meaning and relation to each other as well as previous knowledge.
In terms of effectiveness for remembering, relational rehearsal is far better than simply repeating it. Remembering something from maintenance rehearsal is difficult and requires many repetitions.

When trying to remember something, the content can be processed on three different levels: shallow processing (are two words in same typeface?), medium processing (do they rhyme?) and deep processing (are they synonyms?). Unsurprisingly, deeper processing provides better memory.

For purposes of memorizing, there is no difference in ability to remember whether you have the intention to learn or not (intentional learning vs. incidental learning) – but approach is important.

Deep processing influences subsequent *retrieval of information*, which promotes recall.
Memory connections allow one memory to trigger another memory until the desired memory is retrieved. The more connections to a given memory, the easier it is to retrieve.
Thinking about meaning and relations results in more connections being made.

Elaborate processing is to e.g. decide if a given word fits into a given sentence or not. For this task, both deep processing and elaborate processing is needed. It appears that these two methods of processing together produces better recall than deep processing alone, which suggests that thinking about something in multiple ways increases retention. Idea is that it creates more *retrieval paths*.

The more connections we can make to new material, the easier it is to remember.
Mnemonics are good for remembering material but is not good for *understanding* the material.

Connection between learning and retrieval

You remember material better if the environment in which you learn matches the environment that you retrieve the information. If you study a text in a noisy environment, you recall it better if you are also tested in a noisy environment. Same goes for e.g. being in the same room. This phenomenon is called **state-dependent learning** or **context reinstatement**.

A similar effect is seen if participants memorize words by their meaning or sound and is then questioned by meaning or sound. If you memorize a word by its meaning, you perform better when you are asked questions about its meaning. Likewise, remembering by sound prepares you for questions regarding sound.

If you are given a cue e.g. heavy piano and told to remember piano, you are much more likely to remember the word piano when given the cue heavy, as opposed to e.g. musical instrument. This is called **encoding specificity** and shows a bias in how we learn.

There are two types of memory retrieval: **recall** (given a cue, find the needed information) and **recognition** (given a picture of a man, confirm that he matches your memory).
Ability to recall is highly dependent on the connections you have made.
For recognition, you can use recall to retrieve the source memory and answer based on that, but if unavailable you may still feel a sense of **familiarity** and make judgements based on that. This is experienced when you e.g. see a celebrity that you cannot recall but know you have seen before.

Implicit memory

If not directly asked whether they have seen a word recently, participants are still primed for that word and is thus an example of implicit memory (unconscious influence).

In a **word-stem** task where participants are given a three-letter sequence, e.g. CLA, and are tasked to complete the sequence to produce a word, e.g. CLASS or CLAM, they are more likely to use a word that they have encountered recently, even though they have no conscious memory of it.

Therefore, we are motivated to distinguish between **explicit memory** and **implicit memory**.
Explicit memory is revealed by direct memory testing – asking about a specific event or item.
Implicit memory is revealed by indirect memory testing – priming effects not consciously used.

Because of implicit memory, people may sometimes misjudge recently seen names as names of celebrities because they have a sense of familiarity.

Just like repeatedly seeing a person improves your detectors' ability to recognize it (practice), even just *thinking* about the person has a similar effect. If the person changes something about their appearance, e.g. hairstyle, you will however notice a decrease in **fluency** and thus less familiarity.
It can be said that **fluency** leads to **familiarity** when exposed frequently.

Amnesia

Patients that hit their head are often subject to **retrograde** amnesia in which they are unable to recall events just prior to their accident.
Other forms of amnesia, called **anterograde** amnesia, can have the reverse effect and cause disruption of memory for events *after* the onset of amnesia.
In many cases, patients with amnesia will encounter both forms of amnesia.

Patients suffering from Korsakoff's amnesia (like H.M., unable to retain new memories) only seem to have their **explicit memory** impaired, but still improve on indirect memory testing (i.e. priming).

Remembering complex events

We often make errors when remembering events. Sometimes, we claim to remember something that never even occurred!
Our memory is influenced by our **prior knowledge**. In a study were participants were asked to wait in a professor's room and then later asked to recall what they saw in that room, most of them answered items that typically appear in a professor's room. For example, 1/3 of participants remembered seeing books, even though no books were present in the room.

Hypothesis: when storing similar events, they tend to **blend together** with no clear boundaries, as the events themselves share a lot of connections. These connections make it easier to recall information but may lead to **intrusion errors** (other events intrude your recalled memory).

When given a sequence of semantically related words and then later asked if a specific word was in that list, errors likely occur if a word not in the list is semantically related (DRM procedure).
Schematic knowledge is the general expectations for a given setting and helps us recall an event.
E.g. restaurant visit consists of schematic knowledge (how eating at a restaurant plays out) plus some memory of the concrete things that happened during that specific restaurant visit.

Avoiding memory errors

As time between an event and memory retrieval – the **retention interval** – increases, you gradually forget more and more of the event, forcing you to rely more on reconstruction to fill the gap.
You will also have more difficulty determining which details were part of an event and which are simply related to that event or concept – called **source monitoring** (to determine source of a detail).

Several reasons for memory loss are proposed: relevant brain cells may die off, connections perhaps need to be constantly refreshed or new memories interfere with the old ones (**decay**).
Another theory is **retrieval failure**: as time goes on your perspective on things change. As retrieval is said to be **state-dependent**, it may be more difficult to find a retrieval path as time progresses.

When interviewing rugby players about their opponents, researchers found that the more games they played, the less likely they were to remember players' names when time was held constant.

There is no correlation between memory confidence and memory accuracy, just like there is no correlation between emotion towards a memory and memory accuracy.

There is some correlation between memory accuracy and **speed of retrieval**.

The **self-reference effect** makes memories that you are directly related to (and not just observing it) more memorable and allows for better memory accuracy. This can however also lead to errors, as we tend to remember e.g. our grades as better than they were.

For **flashbulb** events (e.g. the attack on world trade center), participants claim to remember details of the event very clearly, even years after the event. The correctness of these details is highly dependent on the **consequences** of that event. If it is very impactful to the participant, it will be remembered better than if it non-consequential to the participant.

Traumatic events can for some persons be remembered in great detail and for a long time, while others may not remember them at all. The degree of remembrance may depend partly on the person's age at time of the event – **childhood amnesia** is likely to fade early life traumatic events.
In other cases, the brain may try to forget certain events as a means of **self-protection**.

Periodically retesting (rehearsing) material can dramatically increase long-term retention.

Memory networks

Memories are represented by network connections formed in our brain, not just retrieval paths.
Representations of memories are considered **nodes** and connections are considered **associations**.

When given a cue, that cue is looked up in the network and the graph is traversed until the target memory node is found.

Nodes receive activation from their neighbours – the **activation level** of the node increases. Once the activation exceeds a **response threshold** it *fires*. When fired, the node itself is now a source of activation, increasing the activation level of its neighbours.

Activation is assumed to accumulate, so if multiple nodes activate a target node, their summed activation level may be enough to reach its response threshold and fire it.
If a node has recently fired, it may also be warmed up and be more easily fired again.

This theory explains why we more easily recall if given multiple **hints** towards a target memory.

Tests of the network claim

When testing speed of retrieval for participants, one can give them a sentence, e.g. a robin is a bird, and then measure the time it takes for a participant to answer whether the sentence is true or false. Researchers find that the strongly the association, the faster a response is. It is faster to conclude that a robin is a bird than e.g. a penguin, even though it *is* a bird.

Another factor influencing speed is the **degree of fan**. We have comparably more knowledge about water than e.g. aardvarks. Therefore, the outgoing activation from water to each of its neighbouring nodes is smaller compared to the aardvark, and the response threshold may thus not be met.
As such, retrieving knowledge about something related to an aardvark should be faster than for more broadly used terms like water.

Special **input nodes** within the network have regular associations but get their inputs from *detectors* such as eyes, ears and so on. In this way, an input node for e.g. the word CAT is associated with the cat node within the network.
When we initiate a search, we start from an input node and traverse the network.

According to some, each node might represent a single **concept** (prototype or exemplar).

The **ACT** model suggests that models represent its information by **propositions**. An example of such a proposition is that "children love candy" or that "dogs chase cats".
This model distinguishes between two kinds of nodes: **type nodes** and **token nodes**. Type nodes are propositions true for the entire category, while token nodes are only true for a specific instance of that category.

People in the **tip of the tongue (TOT)** state know that a given name is somewhere in their vocabulary but cannot recall it. In such cases, one might know the approximate word e.g. that it sounds like "secant" when trying to recall "sextant".
The TOT phenomenon contradicts with the network notion, in which we would expect to easily recall the word if we are in the vicinity of it.

One proposal to explain the TOT phenomenon is the concept of **winner-takes-all system**, in which nodes compete for the most activation. A winning node is said to produce a **retrieval block**.
If a node receives enough activation, it will inhibit its neighbours to decrease their activation and ultimately shut them down.
If we attempt to retrieve some node and it is shut down by another node, this could explain the TOT state. Best bet is then to wait until the winning node has cooled off in order to recall correctly.

Connectionist networks

In this type of network concepts are represented by a pattern of activation. Computer might be represented by nodes B, C, H, F and if we then need to recall an associated term "MacBook", we might need those nodes to activate other nodes D, G, T that might represent a MacBook.
Therefore, such a network relies heavily on **parallel, distributed processing**.

This way of processing allows **simultaneous multiple constraint satisfaction**, which states that multiple "processes" within the brain tries to locate a node that best fits a constraint they have been given and the overall best-fitting node (in respect to all process results) is selected.
In order to steer retrieval in the right direction, the network has **connection weights**. If two connections are activated at the same time, their connection is strengthened.

Prototypes

A prototype represents the "center" of a category, e.g. the ideal dog. Depending on which dogs people have encountered, they might have different prototypes for a dog.
Therefore, "knowing" what a dog is simply means that you have a mental representation of the prototype.

Category membership for prototypes is a graded membership, and you can thus say that one animal is more "doggie" than others. The outer boundary of a category is an area in which it is difficult to determine the category an object belongs to; this is called a **fuzzy boundary**.

People's typicality rating of the category birds follows a graded membership curve, where the ideal (center) is very "birdie" and e.g. a penguin or a bat has a very low rating.

An object may be part of multiple categories, but people generally refer to it using a **basic-level category**. For example, people would typically categorize a Windsor chair as a chair rather than a Windsor chair. On the other hand, people may not use the most-basic category *furniture* when describing a chair.
There is a natural **basic-level categorization** that people use, and it is often a single word, e.g. *fruit*.

Exemplars

In cases where we have very little knowledge or encounters on an object, we tend to use an *exemplar*-based reasoning.
We have a mental image of all the objects we have seen from a category, and then compare a new encounter to those images. If they are sufficiently similar, we categorize it as that.

For items that we encounter frequently, e.g. apples, our memory search is incredibly fast due to priming. Less frequently seen fruits may take longer to process as they are less primed.

An exemplar-based learning preserves information about variability. Even though a pizza has a different shape than a regular pizza, it may still be a pizza. This example is easily supported in an exemplar-based approach while prototyping would consider it less "pizza-like".

Depending on our knowledge of a given category, we might use mostly prototype-based or exemplar-based reasoning.

Category membership and resemblance differs depending on the item.
When asking participants if a smashed lemon is still a lemon, they reason based on its genetics.
When asked whether a toaster could be turned into a coffeepot, they all agree that is it possible.
People thus reason differently for **living** and **non-living** items in terms of categorization.

When judging resemblance, different features have different levels of importance (weights) when we determine whether something belongs to that category or not.

Categorization via resemblance is a **heuristic strategy**: efficient, but not always perfect accuracy.

Participants learn a category's features more easily if they know how they relate to each other.

Similarity is the effect used in reasoning in which you would conclude that something is likely true for category B if it is true for a similar category A.

Language

The structure of language is: sentences, phrases, words, morphemes, phonemes.
Examples of morphemes: the, umpire, s, talk, ed, …
Phonemes are the smallest unit and is an international way to describe pronunciation.

Speech sounds can be controlled by restricting airflow – **manner of production** – as well as position of tongue.
We also distinguish between sounds that are **voiced** – produced with the vocal folds vibrating – and those that are not. Examples of voiced sounds are [v], [z] and [n], while [f], [s] and [t] are unvoiced. If you place a hand on your throat and say e.g. [n], then you will feel it vibrating as opposed to [s].

Finally, sounds can be categorized based on where the airflow is restricted – **place of articulation**.

When speaking, there is no silence in between each word, although humans perceive such a gap. If you listen to a foreign language, it appears as though they speak very fast, while it is mainly because the mind cannot separate the words that you hear.
Hence, when analysing individual phonemes digitally, you have to perform **speech segmentation**.

Coarticulation is a term for the fact that phonemes “overlap” when we speak, e.g. we prepare for the [o] sound when pronouncing the [s] sound in *soup*.

The 50 most commonly used words in English make up half of the words we hear every day.
English language has a total of 40 phonemes.

We supplement what we hear with our own knowledge about the meaning of those words.
One proposal is that when we hear the first phoneme of a word we start searching our vocabulary and narrow down our options further as soon as we hear the second phoneme, and so on.

In other cases though, it is evident that we are guided by our broader knowledge of words and context. If one or more phonemes are replaced by noise, we can still make out which word it was and in fact perceive the whole word plus a noise. This is called the **phonemic restoration effect**.

Categorial perception is a term that refers to the fact that we are much better at distinguishing *between* categories of sound than to distinguish variation *within* a category.
Said differently, we are very sensitive to the difference between a [t] and a [d], but very insensitive to variations of e.g. [t].

What a word refers to is called a **referent**. An example of a word with meaning but no referent would be the word “unicorn”.

In spontaneous speech, we make a lot of performance errors. Therefore, we need to examine language **competence** rather than language **performance**.

Linguistic universals are rules that apply to all human languages. The subject tends to precede the object in 98% of languages. The sequence of subject before verb is preferred in 80% of languages.

Garden paths are sentences that are temporarily ambiguous. You are initially led to one interpretation but this interpretation then turns out to be wrong and you revise the meaning. Therefore, you should in theory wait until the end of the sentence to interpret the meaning.

Minimal attachment is the idea of parsing a sentence using the simplest syntactical structure that accommodates the currently read words. This can lead to errors for garden paths, but generally works pretty well in everyday use.

Judgement

To draw inferences based on a pattern or a few examples is called **induction**.
Inductive conclusions are never guaranteed to be true, but they are *likely* to be true.

Descriptive account of human induction is telling us how a process ordinarily proceeds, whereas a **Normative account** tells us how things *ought to go*.

Attribute substitution is done when you try to evaluate some point but don't have easy access to all the information required. You therefore rely instead of other aspects of the experience – e.g. when trying to evaluate how well you will do on the exam, you consider how well your friends did to access a *frequency*.
If you can't think of any friends that failed the exam, then you conclude that you are likely to pass. This principle is called the **availability heuristic**.

Relying on the availability heuristic will often make **unusual events** seem more frequent as they are more available to you in memory than other events.

Another way to determine e.g. if David is a liar is to evaluate whether he *resembles* a liar. This is called a **representativeness heuristic**.

Relying on the representativeness heuristic makes for **stereotypes** of the sort: if you have met one lawyer, you have met them all!

Anchoring is the act of making a ballpark estimate based on feelings and then adjusting that anchor. The problem, though, is that we often make too little adjustments and thus are biased.

Humans tend to see **covariance** in data even though there is none – **confirmation bias**.
When we see data that we have expectations of we estimate covariance pretty well.
When presented with data that we have expectations of, we overestimate covariance massively.

We are more alert to evidence that confirms our beliefs than data that challenges that belief.

Neglecting the **base rate** is a common problem – e.g. considering a case of a shy professor; does he study Chinese or psychology? Many people would answer Chinese because of the stereotype that Chinese scholars are shy, but they forget that there exists many times more people studying psychology than Chinese.

Base rate neglect is caused by attribute substitution – when we substitute categorical membership with a representativeness heuristic, people tend to ignore sample sizes.

When making judgements, we commonly use availability and representativeness heuristics, but often we are also able to tell when *not* to use them – i.e. when they are unreliable.

Researchers propose that we have two systems, a **dual-processing**, in which System 1 corresponds to heuristics and System 2 is a more sophisticated way of judging (but also slower).
Only if the problem cues need for System 2 will we use it, otherwise we rely on System 1.

Phrasing of base rate as "10 of out 1000" triggers System 2 more frequently than "1% of …".
Participants also perform better when base rate has an obvious cause-and-effect role.

Judging is a **skill** that can be improved upon with proper training.

Reasoning

A process in which we start with claims that we count as “given” and ask what follows from those premises is called **deduction**.
Deduction is used to make predictions about future events and helps us keep our beliefs in touch with reality.

Disconfirmation is much more valuable than confirmation, but people tend to seek out evidence that confirms their belief – **confirmation bias**.
When people encounter disconfirming evidence, they are often quite sceptical about and seek flaws for it to not challenge their beliefs.

Even when disconfirming evidence is undeniable, people sometimes ignore it – **belief perseverance.**
People tend to perform selective memory searches that confirm their hypothesis.

Participants are remarkably bad at reasoning about **syllogism**, e.g. if all S are M and all P are M, does it follow that all S are P?
If a syllogism’s conclusion is something that people believe to be true, they are more likely to judge the logical reasoning as correct – **belief bias**.

People often make mistakes when evaluating **modus tollens** logical rules:
if P is true, then Q is true
Q is false
therefore, P must be false => incorrect reasoning, but people believe it anyway.

People make more errors when problems are abstract (using variables) and are bad at negations.

We learn general **pragmatic reasoning schemata**, rules for common problems, e.g. if A wants to take a certain action, A needs to be given permission. If one can alter a logical problem to make use of pragmatic reasoning, performance improves significantly.

Another way of reasoning is by use of **mental models** in which one imagines e.g. a room full of people and then give people within that room the attributes of the given problem.
It is shown however, that the more mental models needed to solve a logical problem, the more errors are likely to occur.

In decision making, we must often measure options that are incomparable. Within one model, however, we can measure the **expected value** of each option using the simple equation:

Expected outcome = (probability of outcome) x (utility of outcome)

In complicated cases with multiple factors, each factor is calculated and the summed.

One can **frame** a problem in different ways to manipulate people’s chances. If a frame casts a choice in terms of losses (i.e. a negative frame) people tend to be **risk-seeking** to minimize losses, whereas people are **risk-averse** when contemplating gains (i.e. positive frame).

When making decisions, people generally do not try to maximize utility. Instead, people make **reason-based choices**, in which we make decisions that we feel good about, i.e. are reasonable.

Emotion is also a large factor for decision-making. If one feels dread towards e.g. nuclear power, they are likely biased against that option, despite its higher expected outcome.

Social cognition

The "interacting individuals" approach has emerged within the last 10 years.

Main functions of the social brain (primarily the **amygdala**): read mental state of the person we are interacting with based on their actions, and make predictions about future behaviour on the basis of that state.

Theory-theory (TT) proposes that we infer mental states of others on basis of our own mental state. Hence, we do not experience the mental state of others, we simply infer them.

Simulation theory (ST) suggests that we simulate actions of others by activating the corresponding representation of those within ourselves. As such, we experience others' mental state.

Currently, winning theory is the simulation theory due to discovery of **mirror neurons** in monkeys. They are activated when observing actions or emotions in others.

We learn through **imitation**. We anticipate each other's actions and continually adjust our predictions based on the outcome of that prediction (reinforcement learning).