PSYC 10431 - Introduction to Cognition

Introduction (Lecture 1)

Cognition is the ability to recognise sounds, images, etc… **Cognitive Psychology** studies mental events, including hearing, attention, learning, etc… This is a step up from behavioural psychology, which considered the brain a black box which could not be accessed, and hence for every some input, there was the same output. This is not the case in real life. For example, language is generative, and the same input might not yield the same output. The model was not able to account for **language learning**, utility in **perception**, **maze learning**, and a whole bunch of other phenomena. These can only be explained by the **cognitive model**.

Cognition is hence processing different things. We can process multiple things at the same time in two main different ways: **top-down processing** (expectation driven) and **bottom-up processing** (input based).

An example of how cognition is **malleable** is a 1947 study conducted by Jerome Bruner. He asked both rich and poor kids to estimate how big a coin was, without having one in their hands. He found that poorer kids over-estimate the size of coins, and hypothesized that it might be because they were in greater need for them.

Cognition also varies over **time**. Ulric Neisser did a study based on the 1986 Challenger explosion. The day after the event, he asked his students to write down the memories they had of the previous day. 2 ½ years after, he asked the same students some questions about the event. Only 10% answered correctly. Despite having written their thoughts on paper the day after, the students trusted their own memory more than what they had written down previously.

Cognition poses an interesting question for **AI**. AI normally takes data, processes it, and emits an output. How do we define the boundary of what's actually thinking and cognition? As humans, when we think, we also take data, process it, and react accordingly, but our thought process is not the same as AI. Will they ever be able to truly think?

The cognitive approach has also raised questions about the nature of intelligence and thought. An example of this is the **Chinese Room** thought experiment (https://www.youtube.com/watch?v=D0MD4sRHj1M). We don't just simply take data in and spit out a premade answer stored in our brains. How does it work out, why do we have **consciousness**?

There are different ways to study cognition: **Cognitive Psychology** (based on behavioral attitude), **Cognitive Neuropsychology** (seeing how brain damage changes cognition), **Cognitive Neuroscience** (combining both ambits), and **Computational Cognitive Science** (emulating how a real human brain works, which is not AI). The latter is studied here, with the Human Brain Project.

Attention I (Lecture 2): Auditory and Visual Attention Theories

What is attention?

We don't have a full representation of the world through our vision, it's not as if we could see everything and remember it like we were a video camera. Our representation of the world is not rich and detailed, as we only pay **attention** to the details in the environment that are necessary for our goals. We don't notice details unless we are attending to them. Attention can be seen as the **selectivity** of processing.

"Everyone knows what attention is. It is taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought… It implies a withdrawal from some things in order to deal effectively with others."
- William James (1890)

We can distinguish between two types of attention:

- **Focused attention** (selective attention): A situation in which individuals try to attend to only one source of information while ignoring other stimuli

- **Divided attention** (multitasking): A situation in which two or more tasks are performed at the same time

We also have to distinguish between **external** and **internal** attention:

- **External attention**: Selection and modulation of sensory information

- **Internal attention**: Selection, modulation, and maintenance of internally generated information, such as task rules, responses, long-term memory, or working memory

Selective auditory attention

There's selection in our listening, as can be proved thanks to **dichotic listening tasks** (e.g.: https://www.youtube.com/watch?v=8B1NqyB_h5E). You can recognise some basic physical features of the unattended message (pure tone, man or woman), but not "higher-level" semantic properties (e.g.: language, word repeated over and over, backwards speech), according to Cherry (1953).

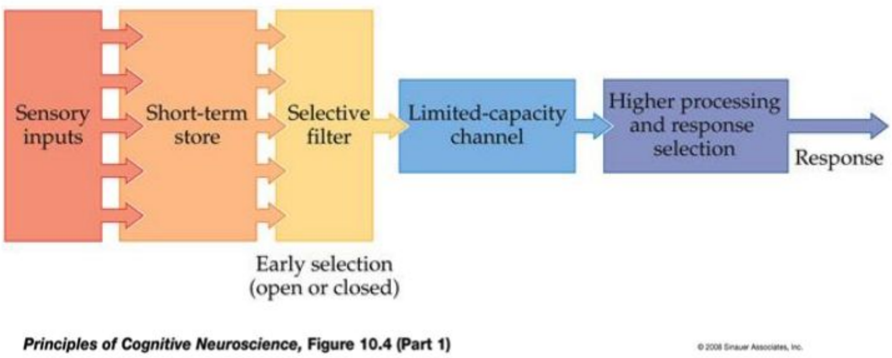
Listeners face two separate problems when trying to attend to a single voice. First, **sound segregation**, where the listener has to decide which sounds (which all overlap) belong together, and which don't. After, the listener must direct its attention to the **sound source of interest**, ignoring all other sources.

What is in the unattended channel is also of significance. For example, Moray (1959) found that the probability of detecting one's own name on the unattended message depends on working memory capacity. Participants with low capacity were more likely than high-capacity individuals to detect their own name (65% vs. 20%). We seem to look out for words of **significance to us**. Li et al. (2011) asked listeners to shadow one message, and women dissatisfied with their weight made more shadowing errors than those without these problems for words like "fat", "chunky", and "slim". **Familiarity** with the target voice is also important, as the accuracy is much higher if listeners have previously listened to the speaker's voice in isolation.

How has auditory attention been explained?

Many psychologist argued that there is a **processing bottleneck** that divides our attention and makes us ignore for the most part the unattended message.

Many have attempted to modelize our attention. **Broadbent's filter theory** proposed that there was an **early filter** in place to prevent overloading a limited-capacity mechanism:

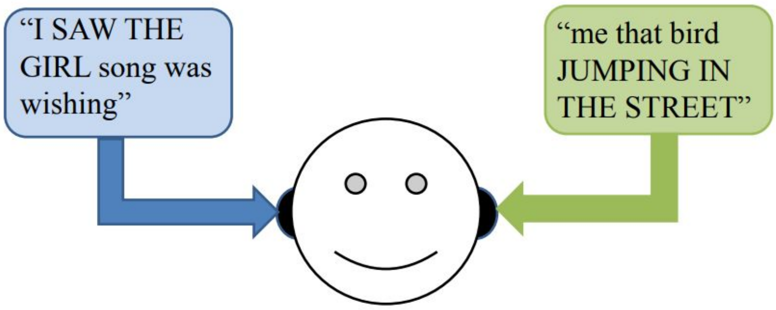


Broadbent's filter theory

However, this model poses an **attentional paradox**, illustrated by the **Cocktail Party Effect** (Moray, 1959). When you're talking to your friend in a party, you can hear your name called by someone else, even when you're actively paying attention to your friend. How can we notice something that we did not attend to? And how does the selective filter allow to follow just one conversation when several people are talking at once? Moray's findings illustrate how about ⅓ of participants reported hearing their name when it was presented on the unattended message.

The fact that we can receive unattended information was proven by an experiment of Von Wright et al. (1975). He paired some words with an electric shock, then conducted a dichotic listening task with those words presented in the unattended message. Participants showed an increased **galvanic skin response**. There was then an unconscious analysis of the unattended message affecting, unconsciously, the physiological measures. Meaning can hence be processed without awareness.

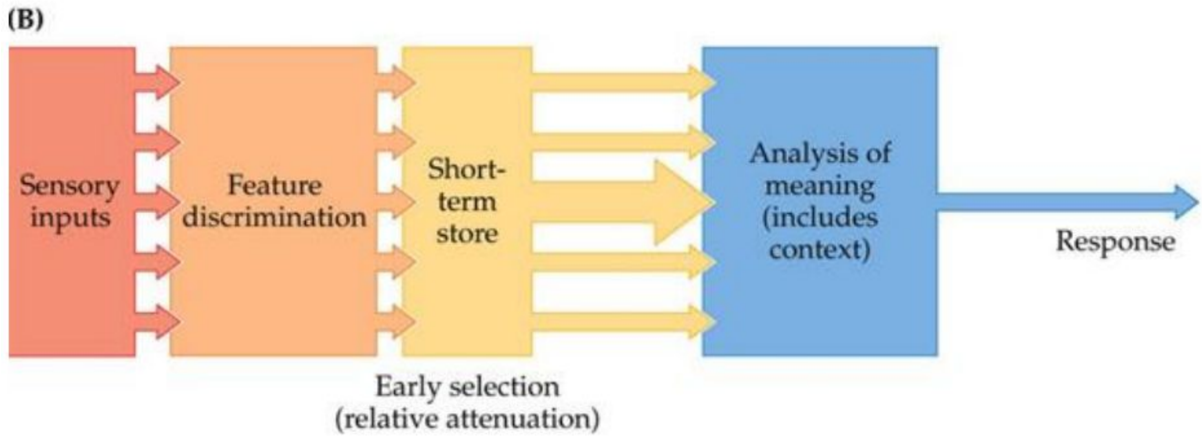
Treisman (1964) had proposed this effect and called it **breakthrough**, which is when participants say a word that was presented in the unattended message. This happened more often when it fit with the context of the attended channel. Ex:



"I saw the girl jumping in the street"

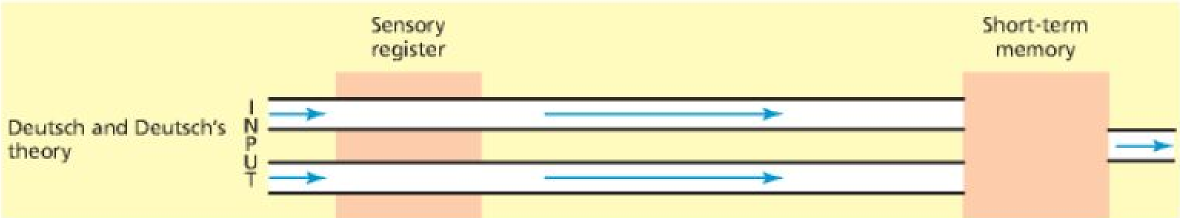
Breakthrough example

Hence, she proposed the **Treisman's attenuation theory**. The unattended input is not completely rejected, but a filter attenuates analysis of an unattended signal. This would mean there's some **early selection** done. If there is insufficient processing capacity to permit full stimulus analysis, later processes are omitted.



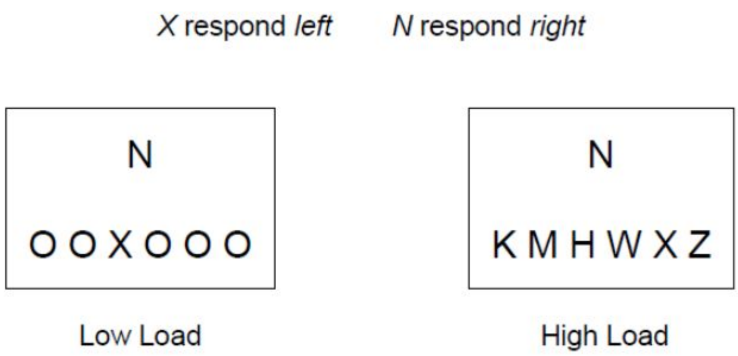
Treisman's attenuation theory model

On the opposite end of the spectrum, the **Deutsch & Deutsch's late-selection theory** suggests that filtering occurs **late**, so all stimuli are analysed equally and the most relevant stimulus determines the response.



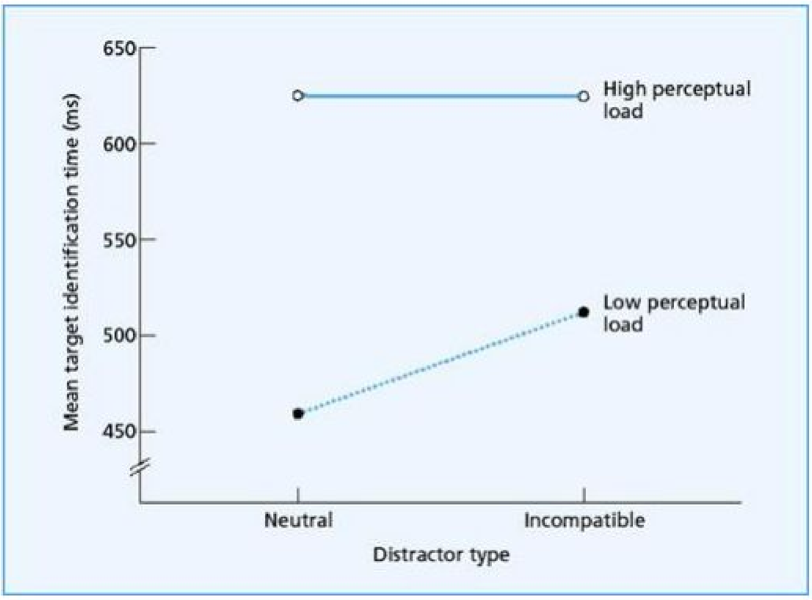
So, when does selection *actually* happen? What if selection is neither only early or only late, but is variable and can occur at different stages? This is what the **Perceptual load theory** (Lavie, 1995, 2000) suggests. Everyone has limited attentional capacity, which is always allocated, and the spare capacity that's not required for the primary task is automatically allocated to irrelevant stimuli.

For example, imagine that the user has to press the left button when they see an *X* in the image, and the right button when they see an *N*.



Low load vs. High load

These were the results:



Difference in selection time depending on perceptual load

It seems that if the perceptual load is high, there’s early selection, and that if the perceptual load is low, there’s late selection. It would be then **variable**.

Here’s a summary of all the different theories:

Summary of theories of attention

Theory	Summary	Pros	Cons
Broadbent’s filter	Early selective filtering out of irrelevant information	Dichotic listening performance – improved detection and ERP amplitudes for attended vs. unattended	Breakthrough effects Some processing of info in the unattended message (e.g. Cocktail party effect)
Triesman’s attenuation	Unattended input is attenuated (not completely rejected)	Breakthrough effects Some processing of unattended message (e.g. Cocktail party effect)	Doesn’t account for Lavie’s effects of perceptual load
Deutsch & Deutsch’s late selection	Filtering occurs late – all stimuli are analysed	Breakthrough effects Some processing of info in the unattended message (e.g. Cocktail party effect)	Dichotic listening performance – improved detection and ERP amplitudes for attended vs. unattended
Lavie’s Perceptual load	Spare capacity not required for the primary task is automatically allocated to irrelevant stimuli	Accounts for early findings AND correctly predicts that a more difficult task will lead to less interference	28

Selective visual attention

As you may have guessed, we’re pretty dumb, even outside of a lab setting (https://www.youtube.com/watch?v=FWSxSQsspiQ). That experiment by Simons & Levin (1998) found that observers did not notice that a person who asked for directions was replaced with another in “real-life.” This is an example of **change blindness**, the failure to detect changes in the visual environment, and an example that it can happen outside of lab settings.

Another popular and easy example of change blindness is the **blindness paradigm** (Ex: https://www.youtube.com/watch?v=bh_9XFzbWV8). To notice the change, the user must fixate a part of the image (number of fixations does not matter), but even then, only around 60% of targets that had received fixation before change were still not detected (Hollingworth and Hendersen, 2002).

There’s also **inattentional blindness**, which is the failure to detect an unexpected object appearing in a visual display (e.g.: the gorilla in the passing balls videos).

So what does visual attention select? Is it **location-based**, **object-based**, or **both**?

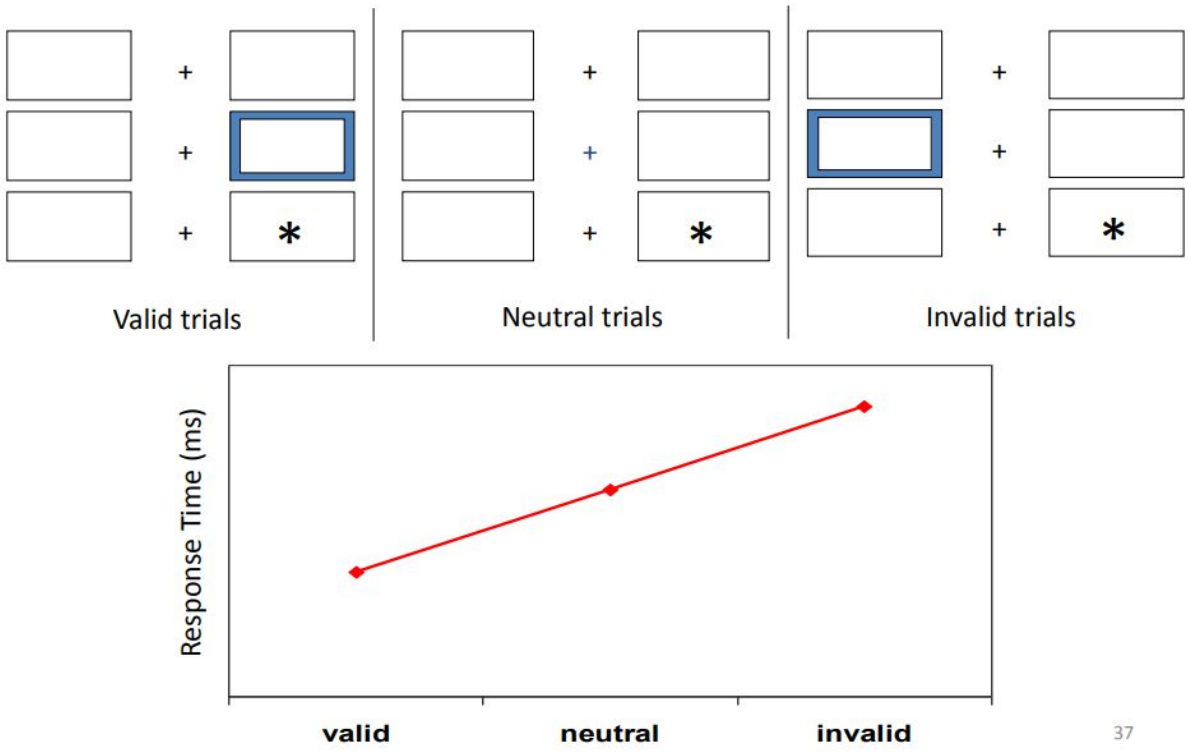
The **location-based** model portrays visual attention as a mental **spotlight**. Posner (1980) suggested that the attentional spotlight can shift to a different visual location without eye movements (**covert attention**). It is as if a spotlight illuminated a small area, with little being able to be seen outside of its beam, and this spotlight could be redirected to focus on any given object.

The **object-based** model portrays visual attention directed to objects rather than a particular region in space. The case of patients with visual neglect support this model.

According to to Posner and Petersen, three separate abilities are involved in controlling attention:

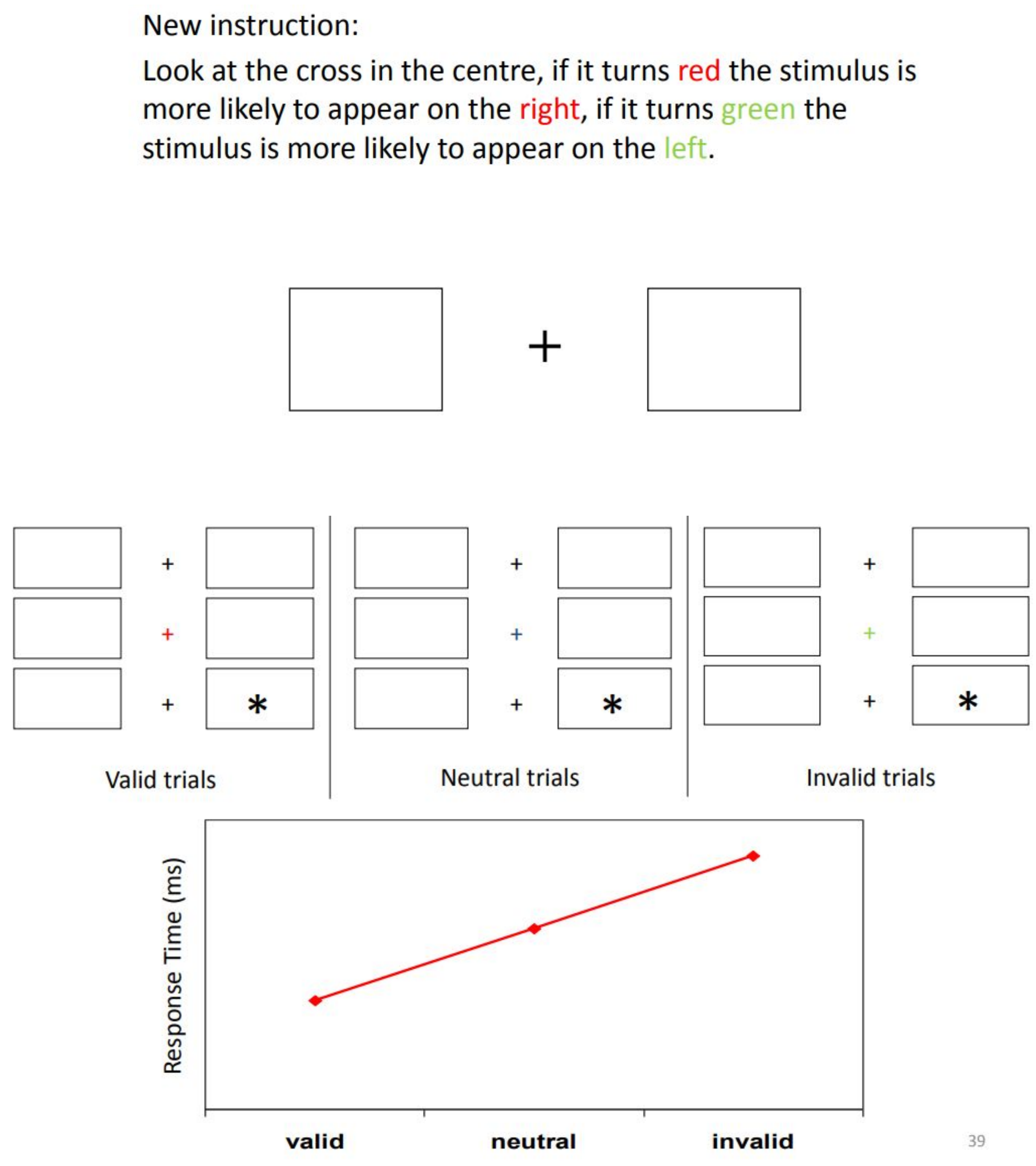
- **Disengagement** of attention from a given visual stimulus. Studies suggest that it’s hard to disengage from objects but not necessarily from a given point in space.
- **Shifting** of attention from one target stimulus to another
- **Engaging** or locking attention on a new visual stimulus

There would be two types of **attentional cueing**. The first one is **exogenous**, which automatically shifts attention. It’s involved when uninformative peripheral cues are presented, and stimuli that are salient or that differ from other stimuli are most likely to be attended to.



Exogenous attentional cueing

The second one would be **endogenous**, which is controlled by the individual’s intentions and expectations, and involved when central cues are presented.



Endogenous attentional cueing

So, is it a **spotlight** or **zoom-lens**? Evidence for the **zoom-lens** model was reported by LaBerge (1983), after he conducted an experiment in which individuals had to press a button when the letter *S* was followed by a single letter *R* (in the next image, and same position). There were two conditions, **letter**:

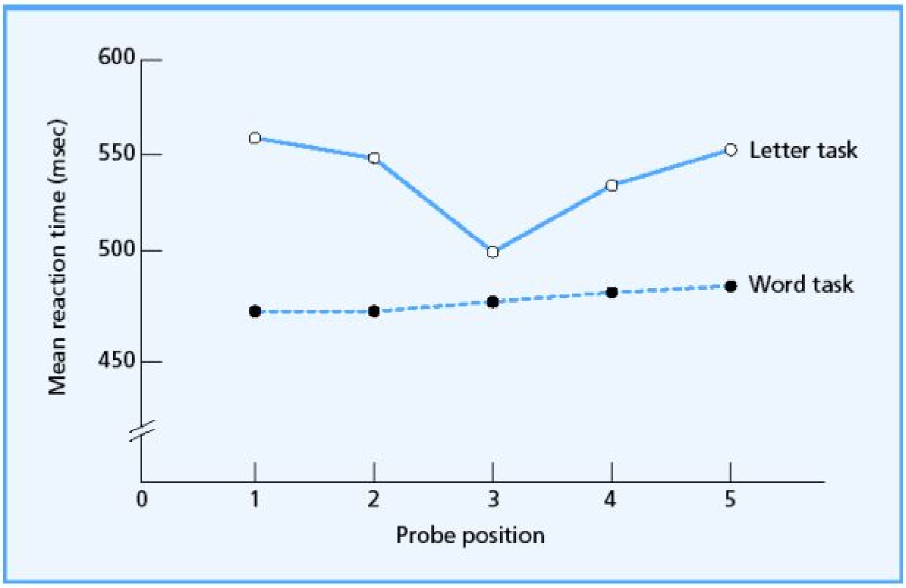
8 5 8 S 5 8 5

R

and **word** (press button after a word is followed by the letter *R*):

B R O W N

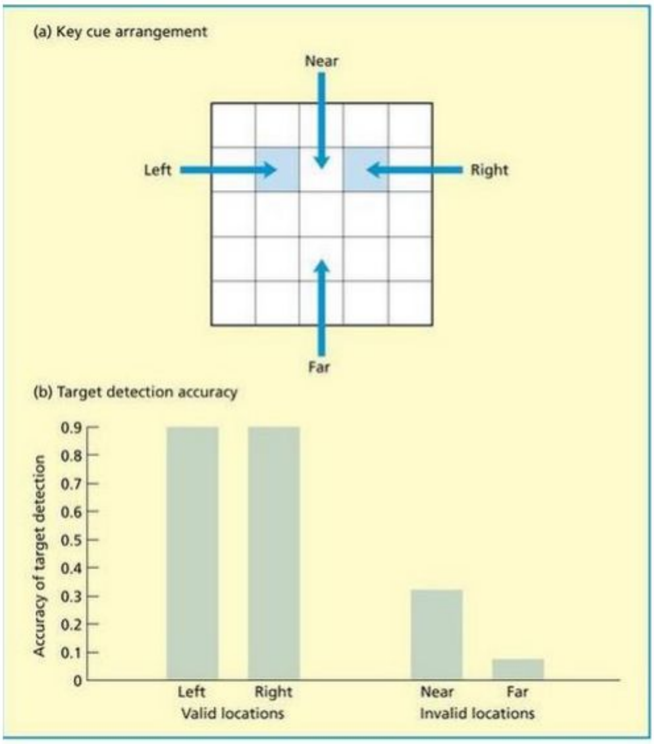
R



Results

The results suggest that the attentional spotlight or zoom lens can have a very narrow beam in the case of the letter task, or fairly broad in the case of the word task.

Awl & Pasher (2000) suggested that the spotlight model was wrong, suggesting a **multiple spotlight** theory, also called **split attention** (cues are the blue squares):



Awh & Pashler (2000)

Participants asked to report 2 numbers in a 5 x 5 grid filled with 23 letters

Cued (80%) valid to two squares. Interested in what happened on the *invalidly* cued trials

Zoom lens predicts space *between* cued locations should be included in the focus of attention – **but this was not the case**

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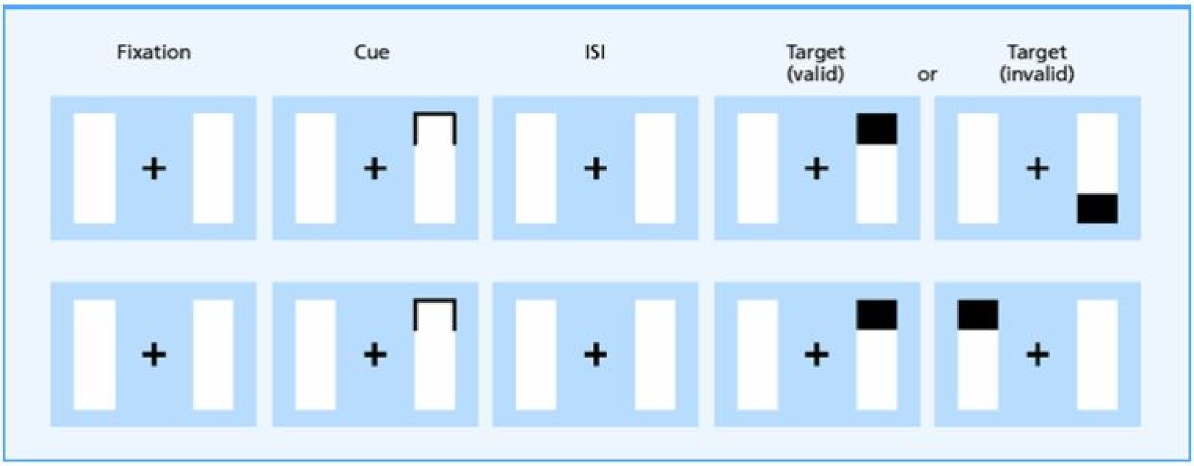
Theory	Summary	Pros	Cons
Spotlight	Attention is focussed on a particular location	Can cue attention to a particular location (covertly or overtly)	Events outside the spotlight can capture attention LaBerge (1983) shows can change the size of the "beam"
Zoom-lens	Attention can be focussed with a larger/smaller "beam"	Events outside a narrow focus can capture attention (e.g., child running into the road) LaBerge (1983) letter vs. word cueing task	Awh & Pashler (2000) show that space between cued locations (in the "beam" are not well-attended)
Split	Attention does not need to be a single region, and can be "split" across locations	Awh & Pashler (2000) show that attention can be allocated to two (or more) ***non-adjacent*** regions of visual space	50

Summary of theories

Egly et al. (1994) suggests that attention is **both location-** and **object-based**. In the next test, performance was best for valid cues, then invalid (same object) cues, and finally for invalid (different object) cues:



Egly et al. (1994) experiment

It would be inefficient to repeatedly attend to any given location when searching the visual environment. Of relevance here is the phenomenon of **inhibition of return**, a reduced probability of visual attention returning to a previously attended location or object. Inhibition of return could exist on both object- and location-based models.

It's important to note that there are other theories like **feature-based attention**. Imagine you're looking for someone in a crowd that you know is wearing red clothes, you would be paying attention to the colour red. Kravitz and Behrmann (2011) found that space-, object-, and feature-based forms of attention **interacted with each other** to enhance object processing.

Recommended reading:

Eysenck, M. W. & Keane, M. T. (2010). Cognitive Psychology: A Student's Handbook (6th ed.).

Most of chapter 5, and some of chapter 4. *Important pages:*

- *153 - 158*: Auditory attention and theories
- *143 - 146*: Change blindness
- *161 - 164*: Spotlight(s) vs zoom-lens
- *174 - 176*: Posner cueing
- *164 - 166*: Location/object-based attention

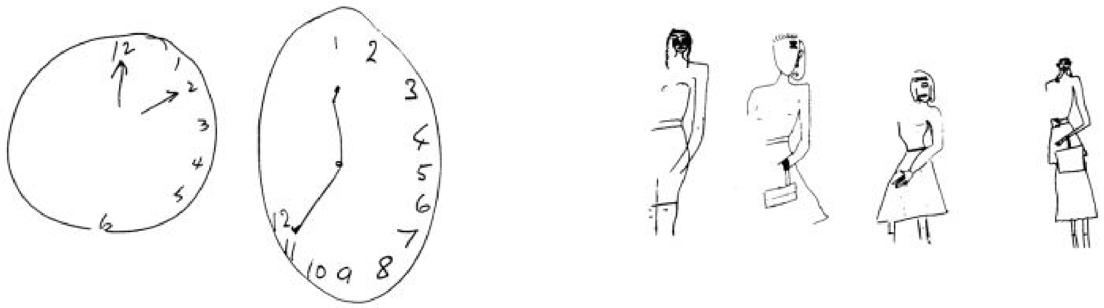
Optional reading and viewing, alongside sample MCQs, can be found in the Blackboard handout.

Attention II (Lecture 3): Neglect, Search and Processing

Left Visual Neglect

Usually following damage in the right hemisphere, this causes the patient to fail to eat food on one side of the plate, and may copy only one side of a drawing. Even when drawing something from memory they'll fail to draw the side on the left. The result is that patients will ignore any stimuli presented on the contralesional side. This is called **neglect**, a disorder resembling **extinction** but more severe, involving right-hemisphere damage typically. (E.g.: https://www.youtube.com/watch?v=ymKvS0XsM4w)

Neglect is a gradient, there's no definite border. It can vary with the number of distractors on display, which suggests our cognition has indeed a limit. Some neglect patients show personal neglect (e.g.: failing to shave the left side of their face), whereas others show neglect for far space but not for near space.



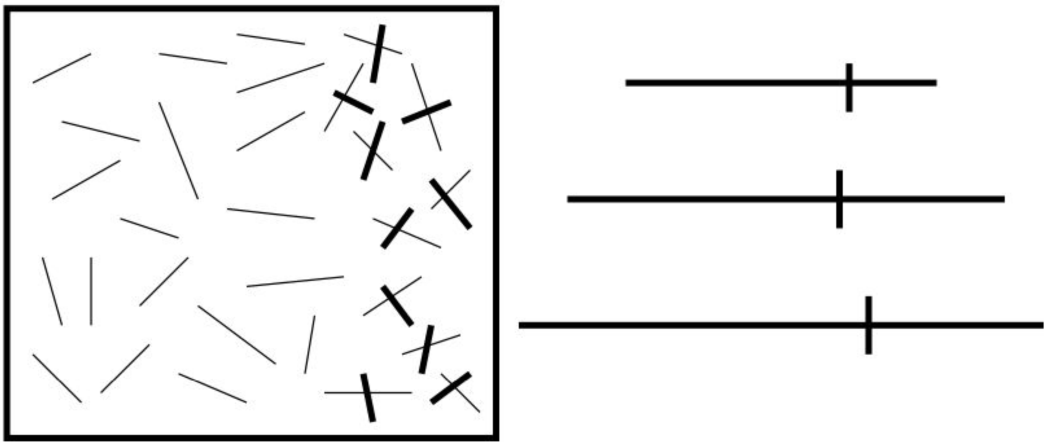
Drawing made by patients with neglect

- **Contralesional**: On the opposite side from where the damage is located
- **Ipsilesional**: On the same side from where the damage is located

Patients with neglect can demonstrate **extinction**, which is the failure to detect contralesional stimulus when ipsilesional stimulus is presented at the same time. The condition of neglect is indeed similar to extinction, but much more severe, as there's generally no need for an ipsilesional stimulus to be presented. They also have difficulty in **disengaging** the attentional spotlight.

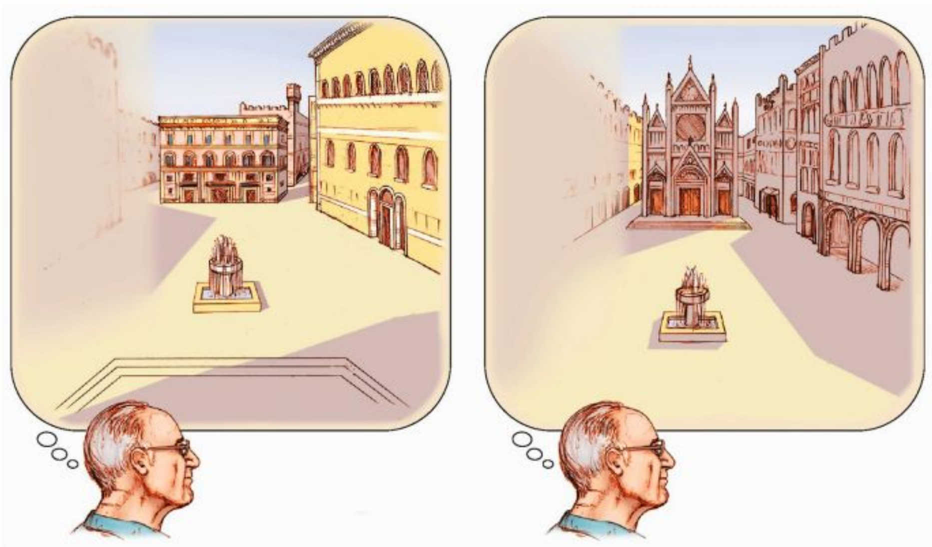
While extinction is by no means the whole story for neglect, it encapsulates a critical general principle that applies for most aspects of neglect, namely, that the patient's spatial deficit is most apparent in competitive situations where multiple stimuli fight for attention.

Neglect and extinction also seem to be reduced in cases where two different stimuli are integrated in some familiar and logical way, reducing competition between the two (e.g.: pouring champagne into a glass vs. pouring champagne on to a ball).



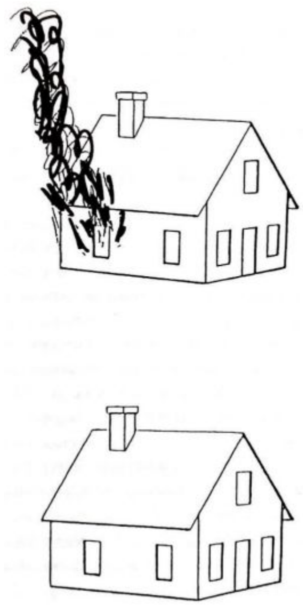
Tests for neglect. On the left, patients were asked to cross out all of the lines. On the right,. They had to cross down the lines in the middle. Note how the spots where the lines have been crossed are the middles of each line if the left side is ignored

There's also neglect in memory, even if they can still recall things. For example, Bisiach & Luzzatti (1978) asked patients with neglect to describe la Piazza del Duomo, first from one side and then from the opposite one. These were the results:



Results from Bisiach & Luzzatti (1978)

Patients were given the following two houses, and were asked to choose in which house they would prefer living in. They all chose the bottom one despite not noticing the fire, with a patient mentioning that the top one looked too hot. There is some processing of information presented to the neglected side, but the patient is not consciously aware.

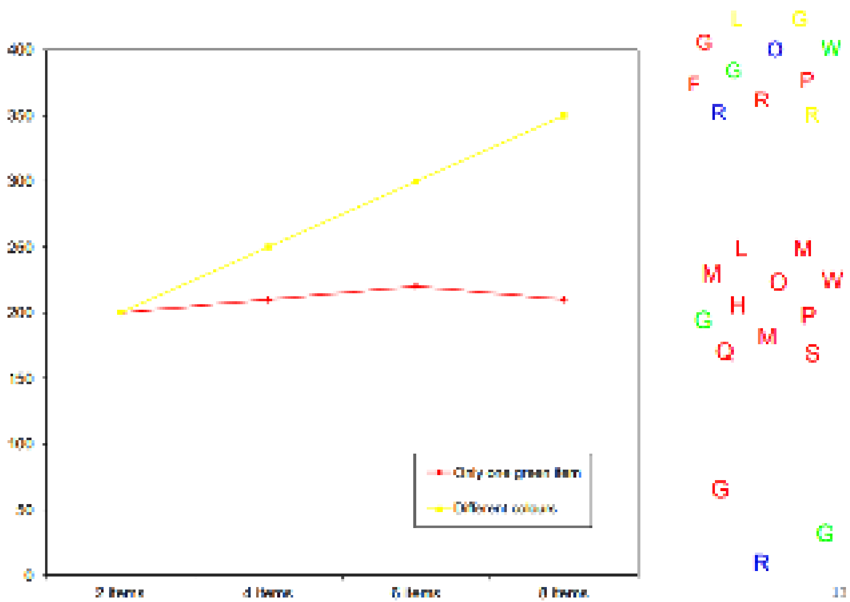


Drawings used by Marshall & Halligan (1988)

We are not sure what's going on in the case of neglect. Is it the exaggeration of normal functioning? Is the presence of extinction suggesting that there is a degree of competition between both hemispheres?

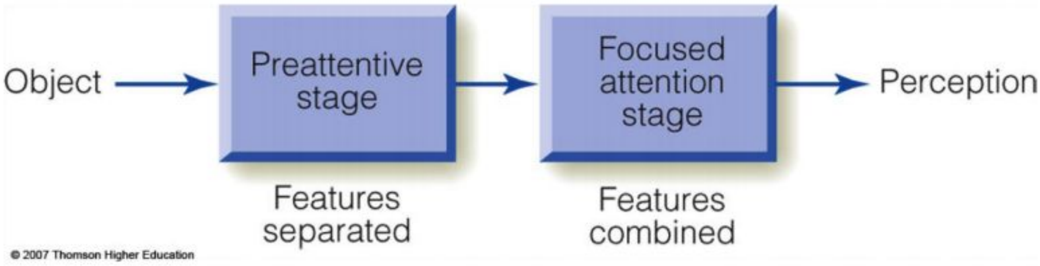
Visual Search

It allows us to look for something in a cluttered visual environment, finding a target among distractors. **Visual search** is the task involving the rapid detection of a specified target stimulus within a visual display. In this next example, a participant had to decide if the target, a green G, which was present on half of the trials, is indeed present or not.



Results, slower reaction time (ms) is better

The **Feature Integration Theory (FIT)**, put forward by Treisman and Gelade (1980), is still the base for many theories today, although it's not quite right,:



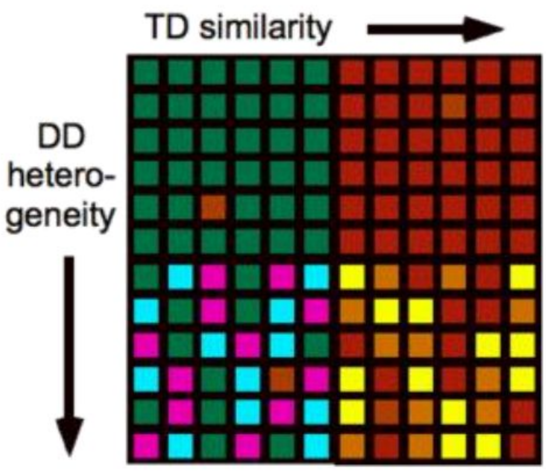
Feature Integration Theory (FIT)

The theory supports that there are two different processes. First, a **rapid initial parallel process**, also called the **preattentive stage**, processes physical characteristics or "features," targeting the targets that are identifiable by simple physical characteristics, which "pop out." All the visual features of objects in the environment are processed together, and it does not depend on attention. Then there's a **serial process**, also called the **focussed attention stage**, in which the features can be combined by focused attending to the location of the object. It can provoque **illusory conjunctions**, which are random combinations of features from two different stimuli to perceive an object that's not present.

Many theorists accept that visual search involves 2 processes, with the first one being fast and efficient, and the second one being slower and less efficient. But FIT has many weaknesses:

- The assumption that visual search is either all serial or all parallel is too strong
- The search for conjunctive (double feature) targets is faster than predicted by FIT
- The nature of non-targets in display is also important
- Not all features are equal

To illustrate, find the red-orange squares like the one in the top-left part. In which quadrant is it most difficult?



There's also the **Threat Superiority Effect**, which demonstrates that not all features and distractors are the same. We are faster to notice something potentially threatening compared to something positive or neutral. It's one of the basis of natural selection.

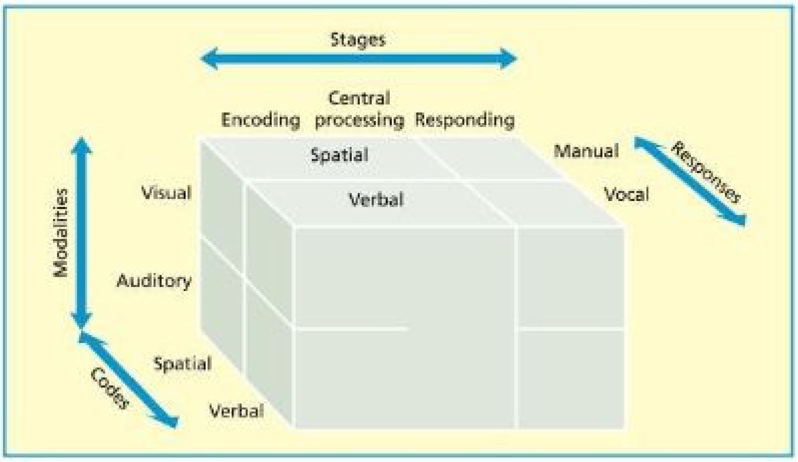
Examples of the Threat Superiority Effect

Divided Attention

Is it possible to pay attention to two things at once? Well, it depends on the task **difficulty**, task **similarity** and **practice**. For example, walking and holding a conversation is easier than driving and texting. Treisman and Davies (1973) found two monitoring tasks **interfered with each other** much more when the stimuli on both tasks were in the **same modality** (visual or auditory).

How can we explain divided attention? Why is performance poorer for two tasks performed simultaneously relative to when the same two tasks are performed separately? We could assume that there is some **central capacity** that can be used flexibly across a range of activities. It has limited resources ("attention"), and any two tasks will interfere provided they require more resources than there are available in the total capacity.

There also are **multiple resources models**. This suggests that there are separate sources of capacity that may be specialised for particular processes. If so, it is clear why the degree of similarity between two tasks is so important. Similar tasks compete for the same resources, and thus produce interference, whereas dissimilar tasks involve different resources and so do not interfere. There is much support for this multiple-resource model.



A proposed three-dimensional structure of human processing resources, Wickens (2008)

Is there a cognitive bottleneck? There's the **psychological refractory period (PRP)** for one. PRP is the slowing of the response to the second of two stimuli when they are presented close together in time. It does not simply occur because people have little practice in responding to two immediately successive stimuli: Pashler (1993) discussed how the PRP effect was still observable after more than 10,000 practice trials. The notion of a **central bottleneck** remains one of the main explanations for a PRP.

Also, is the division of attention **serial** or **parallel**? Well, it seems it's actually relatively **flexible**. Lehle et al. (2009) trained people to engage in serial or parallel processing when performing two tasks together. **Serial** processing was **more effortful** because it required inhibiting processing of one task, but those using **serial** processing **performed better**.

Automatic processing

According to Shiffrin and Schneider (1977), there are two different processes, an automatic and a controlled one.

- **Automatic process**: Fast, unlimited, does not require attention and does not reduce the capacity for performing other tasks. It's parallel processing, unavailable to consciousness, unavoidable and very hard to modify once learnt. It's inflexible and resistant to change.

- **Controlled process**: Slow, limited, requires attention and takes up processing capacity. It's serial processing, available to consciousness, and can be used flexibly in changing circumstances (can turn on and off depending on task demands)

There would also be different levels of automaticity:

1. Fully automatic (controlled by schemas, organised plans)
2. Partially automatic (contention scheduling without deliberate direction or conscious control)

3. Deliberate control by the **supervisory attentional system (SAS)** (new tasks, deliberate planning, problem solving, conflict monitoring, or when a strong habitual response has to be prevented)

The SAS is thought to be somewhere in the **frontal lobes**. Indeed, patients with frontal lobe damage exhibit **dysexecutive syndrome**, having difficulty in planning, organizing & controlling action. Another proof is **utilization behaviour** (Lhermitte, 1983), associated with medial frontal lesions: patients will grasp and utiliza any object that is presented, even if this behaviour is inappropriate.

The **SAS** is also called **top-down control**, **executive functions**, **supervisory attentional system**. There's another problem though, what **controls the SAS**? There would be an **infinite recursion** of controllers going up. This is also called a **homunculus problem**.

Reading:

Eysenck, M. W. & Keane, M. T. (2010). Cognitive Psychology: A Student's Handbook (6th ed.).

Most of chapter 5, and some of chapter 4. *Important pages:*

- *170-174:* Neglect
- *176-180*: Visual Search
- *185-189*: Divided Attention
- *197-199:* Psychological Refractory Period
- *193-195:* Automatic Processing

Optional reading and viewing, alongside sample MCQs, can be found in the Blackboard handout.

Learning I - (Lecture 4)

Habituation

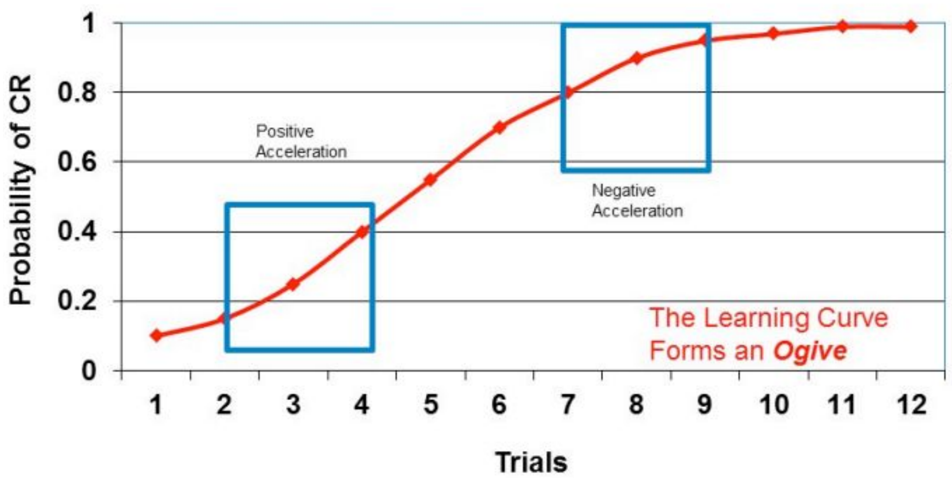
Habituation is the decline in tendency to respond to stimuli once it becomes familiar. This allows us to concentrate on more important activities, as the familiar task becomes automatic. This process relies on **memory**. However, nothing new is **learnt**.

Classical Conditioning

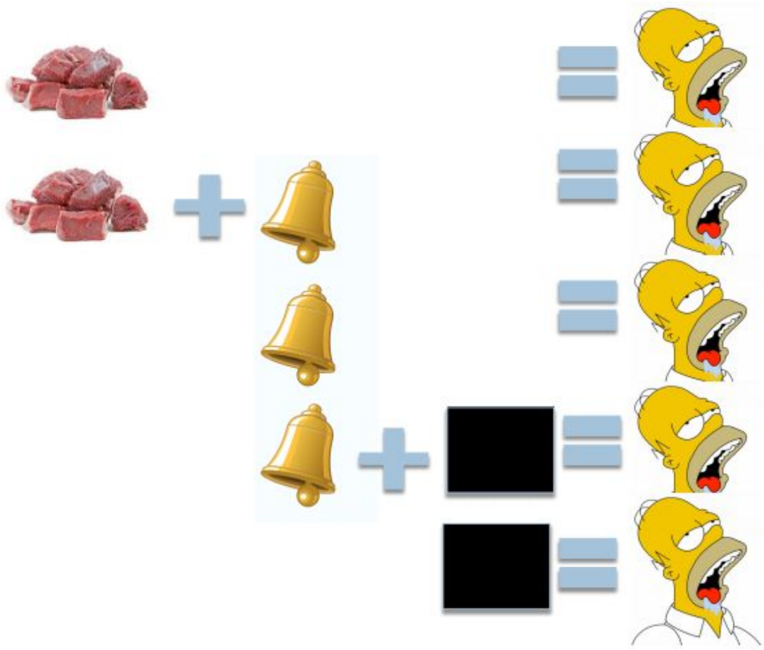
With **classical conditioning**, there's a process where **associations** are either strengthened or weakened. One of the most famous examples of classical conditioning are Pavlov's experiments with dogs. Dogs salivate when:

- Meat is placed in mouth (unconditional stimulus)
- They see meat (unconditional stimulus)
- They see a dish (conditional stimulus)
- They see the person who brings meat (conditional stimulus)
- Hear the footsteps of that person (conditional stimulus)

This reflex of salivation can be either **conditioned** or **unconditioned**. Unconditional reflexes are natural and biological. Conditional reflexes, or **conditioned response** appear after learning (e.g.: learning that there's food in a McDonalds and salivating, even when not seeing the food itself).
By pairing conditional stimuli with unconditional stimuli, we do what's called **classical conditioning** (e.g.: https://youtu.be/zrFtlG3zxtA, US: Eating the Altoid; CS: Computer Shutdown Sound).

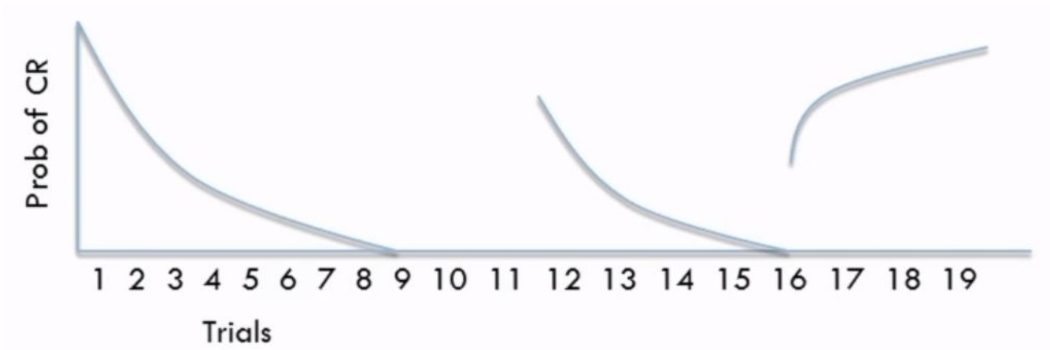


Acquisition of Conditioned Response



Acquisition on 2nd Order Conditioned Response

Once a conditioned response has been learnt, there can be **extinction**, the loss of the conditioned response. If for example an association breaks, there will be less probability over time that this conditioned stimulus will trigger the condition response. There can also be a **spontaneous recovery** or **reconditioning**:



Stimulus disappears day 1, reappears day 11 and 16 onwards (with a faster rate than usual)

After learning this conditional response, there can be **generalisation**: situation where there's a presence of a stimuli that's different but very similar to another stimulus that triggers a conditioned response. In the same vein there's **discrimination**. Some stimuli that prompt a conditional response based on generalisation will be discriminated against when realising they're not in the same category. These won't trigger then the conditional response, and will be **inhibitors**.

Relations between CR and UR

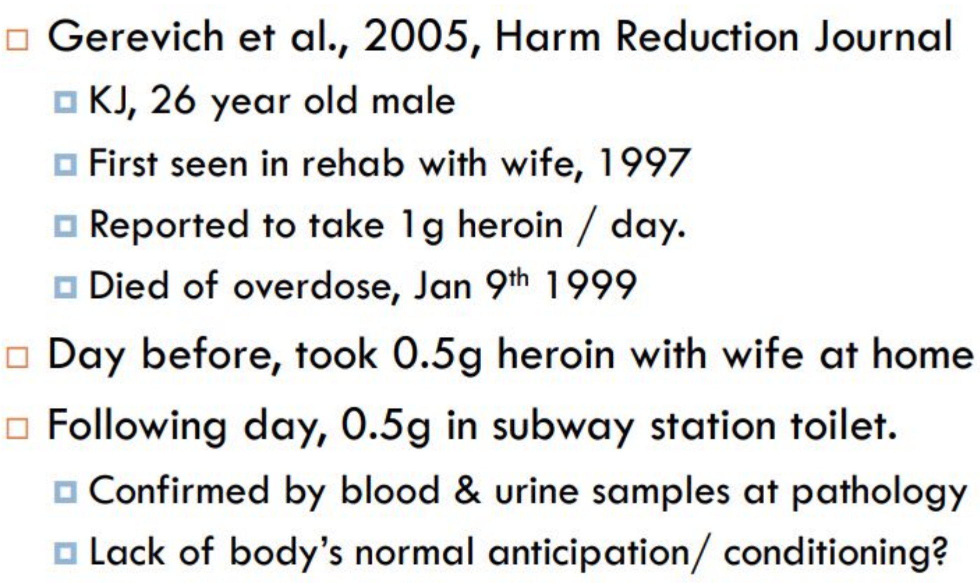
Conditioned responses and unconditioned responses can seem similar in context as they basically are the same, but there are some subtle differences.

For example, in the case of dogs salivating, the unconditioned stimulus (meat in mouth) triggers an unconditioned response that is **stronger** (more salivation, richer in enzymes).

For fear conditioning, there's a fearful anticipation absent in unconditioned responses.

Conditioning and Drug Use

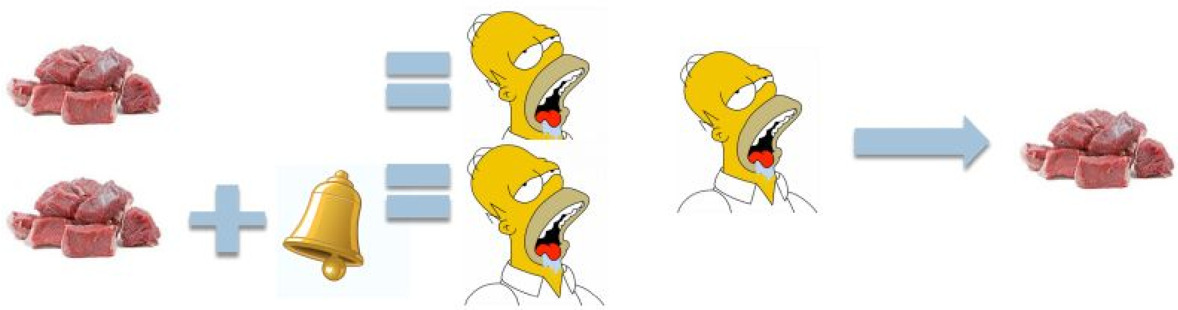
Conditioning is very common in drug use, (e.g.: diabetes patients). As they inject insulin to deplete blood sugar levels, after many injections the sight of the needle will trigger an early physiological response, increasing the blood sugar levels. The conditioned response prepares for the unconditioned stimulus. There's a **compensatory reaction**.



Example of conditioning in drug use (lacking anticipation)

Instrumental Conditioning

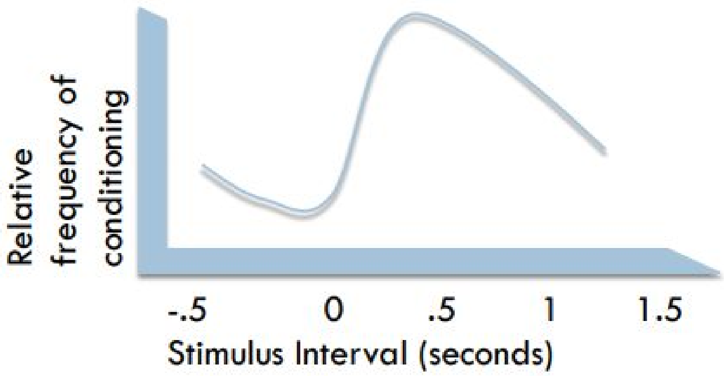
Here, the response depends on the behaviour (e.g.: meat only comes if the dog salivates), works as **reinforcement**.



Working on instrumental conditioning

Skinner is one of the most known psychologists to have worked on instrumental conditioning, especially with birds (https://www.youtube.com/watch?v=xt-ycTMISwg). According to him, the actions aren't just reflexes as they are voluntary. They choose to do the **operants**, actions operated on the environment to bring about change linked to consequence. Animals show learning curves, as there are faster responses following reinforcement.

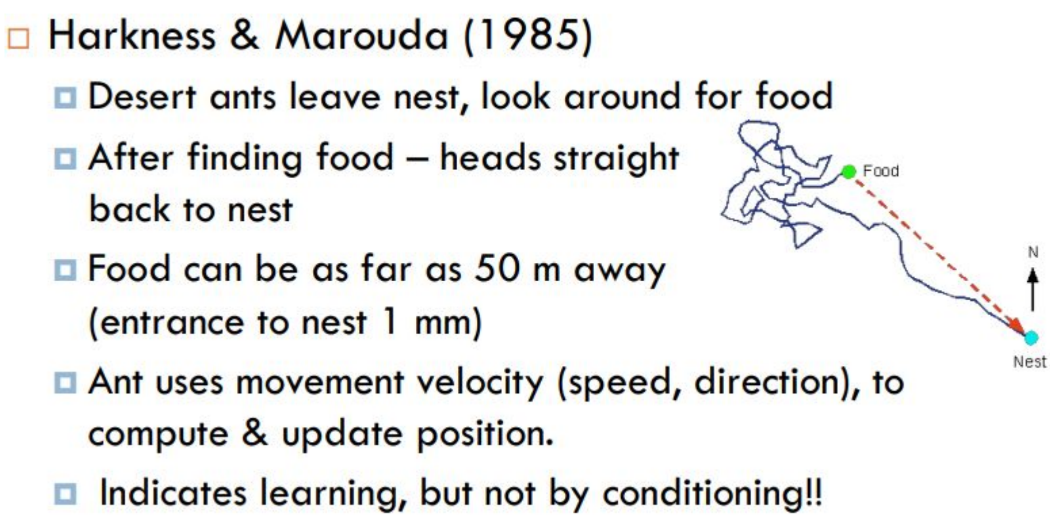
We can get animals to "learn" to a certain extent, through **cognitive learning**, although it can be combined with conditioning (https://www.youtube.com/watch?v=_6479QAJuz8). In order for a stimulus to get a learnt response, there has to be **contiguity** (e.g.: right after the bird does a full turn the food appears). Stimuli also must follow **contingency**, they must occur reliably before the event.



Importance of contiguity

Latent learning

Finally, animals can learn without conditioning by **latent learning**. This means that there is an acquisition of new knowledge without any changes in the behaviour.



Example of latent learning

Reading

- Skinner BF (1976) About Behaviorism. New York: Vintage Books

Learning II (Lecture 5)

This lecture covers learning on humans, and the different methods available. It's based on the Dunlosky (2013) paper (see Blackboard).

Technique	Description
1. Elaborative interrogation	Generating an explanation for why an explicitly stated fact or concept is true
2. Self-explanation	Explaining how new info is related to known info, or explaining steps taken during problem solving.
3. Summarisation	Writing summaries (of various lengths) of to-be-learned texts
4. Highlighting/ underlining	Marking potentially important portions of to-be-learned materials while reading
5. Keyword mnemonic	Using keywords and mental imagery to associated verbal materials
6. Imagery for text	Attempting to form mental images of text materials while reading or listening.
7. Rereading	Restudying text material again after an initial reading
8. Practice testing	Self-testing or taking practice tests of to-be-learned material
9. Distributed practice	Implement a schedule of practice that spreads out study activities over time.
10. Interleaved practice	Implementing a schedule of practice that mixes different kinds of problems, or a schedule of study that mixes different kinds of material, within a single study session

The different learning techniques used by students

Elaborative Interrogation

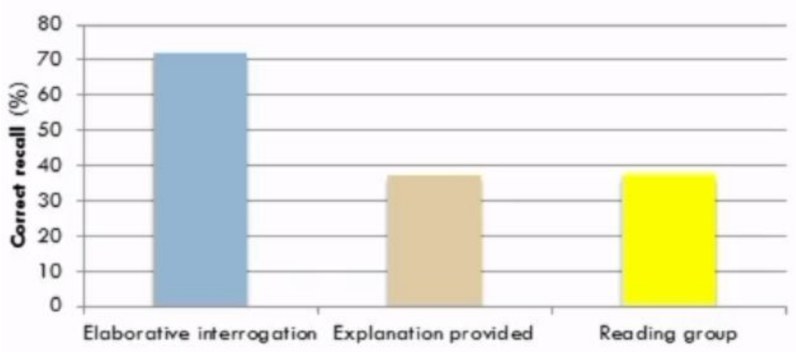
Usually involving "why" questions, we generate an explanation for why an explicitly stated fact or concept is true (Why is this fact true, why does it make sense that…).

Pressley et al. (1987) studied this method, by using three independent groups, giving them a series of sentences. In our example, the sentence was "The hungry man got into the car."

Elaborative-interrogation group	Explanation provided group	Reading group
"Why did that particular man do that"	"The hungry man got into the car to go to the restaurant"	Simply read the sentence.

The 3 levels of the IV

Each group was cued to recall which man performed each action (e.g.: “Who got into the car?”).



Results of the test

It’s believed this works by supporting the integration of new information with existing prior knowledge. Does higher knowledge permit the generation of more appropriate explanations for why a fact is true?

There is little difference in time needed to implement this method compared to passive learning. However, it has some issues, as students need to identify their own target facts, and is not as useful for longer texts. There’s the need of further research to establish generalisability of the effect.

Highlighting and underlining

One of the most frequently reported methods of studying, usually without additional note taking. Fowler & Barker (1974, Expt 1) studied this in a similar fashion to the previous example. All groups had 1 hour to study an 8000 word Science article, and the test was 1 week after with 54 MCQs. They were allowed to review the material for 10 minutes prior to the test.

Active highlighting group	Passive-highlighting group	Control group
Highlight as much of the text as they want. Mark important material.	Read text which had been highlighted by yoked ps in the AH grp.	Simply read the article.

The 3 levels of the IV

Highlighting groups did not outperform controls. Highlighting is useless. Although the active group performance was better on test items for which the relevant text had been highlighted, the info that had not been highlighted was worse remembered. All in all, it may actually hurt performance on higher-level tasks that require inference making.

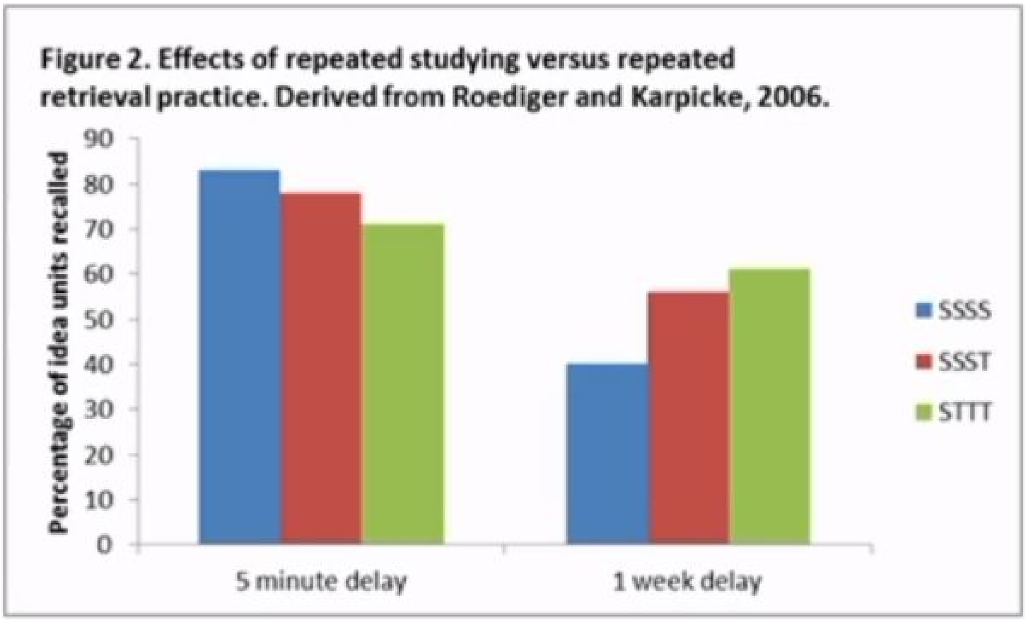
It may also be possible that training is needed to ensure more effective highlighting, and impose a limit to the amount of text that students can mark. Indeed, when there's more highlighting, the information is less distinctive.

Practice Testing

Taking low-stakes practice exams. This is a form of retrieval practice. All different types of tests (MCQs, Fill-in-the-blank, Essay) have added benefits for long-term retention. This method has of course also been studied (Roediger & Karpicke, 2006):

Repeated study:	Single test:	Repeated test:
Passage read 4 times, no test.	Passage read 3 times, then students recall as much as possible.	Read once then recall as much as possible on 3 occasions.

The 3 levels of the IV

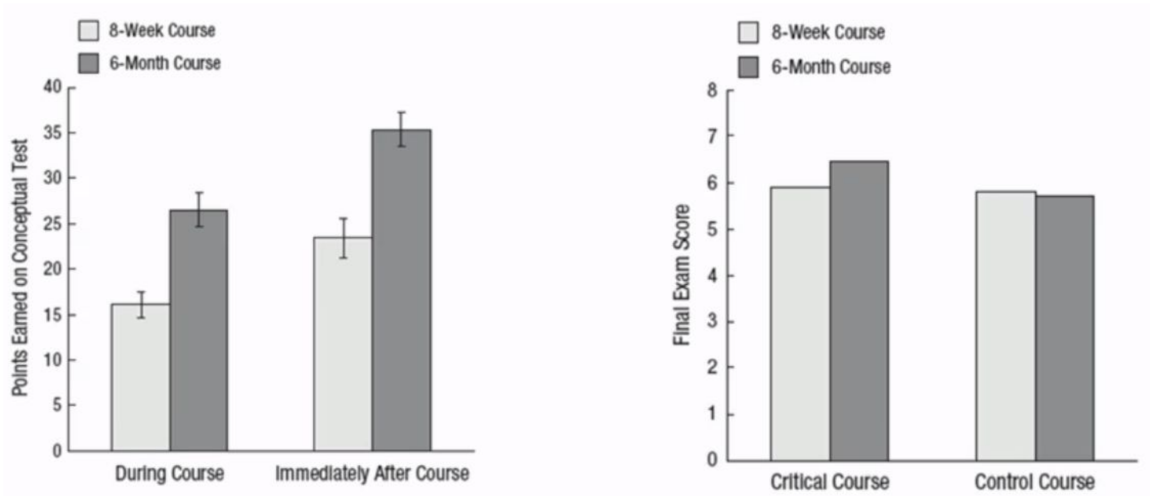


Results

It can be that this method works through **direct effect** (changes that arise from the act of taking the test itself) or **mediated effects** (better learning at next study). The more testing the better, up to a certain point, as there will be the greatest benefit if you continue until you correctly recall everything. If you get it wrong, you should test yourself later again until you get it right. The best implementations would be flashcards and effective note taking (**Cornell notes**).

Cramming vs distributed practice

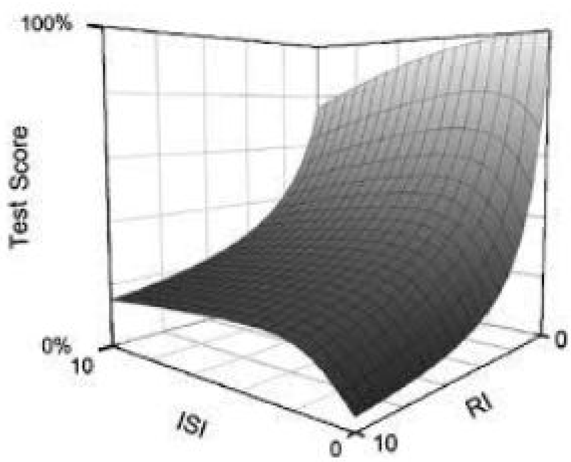
It’s better to distribute the learning practice, as shown by a Bude et al. (2011) study:



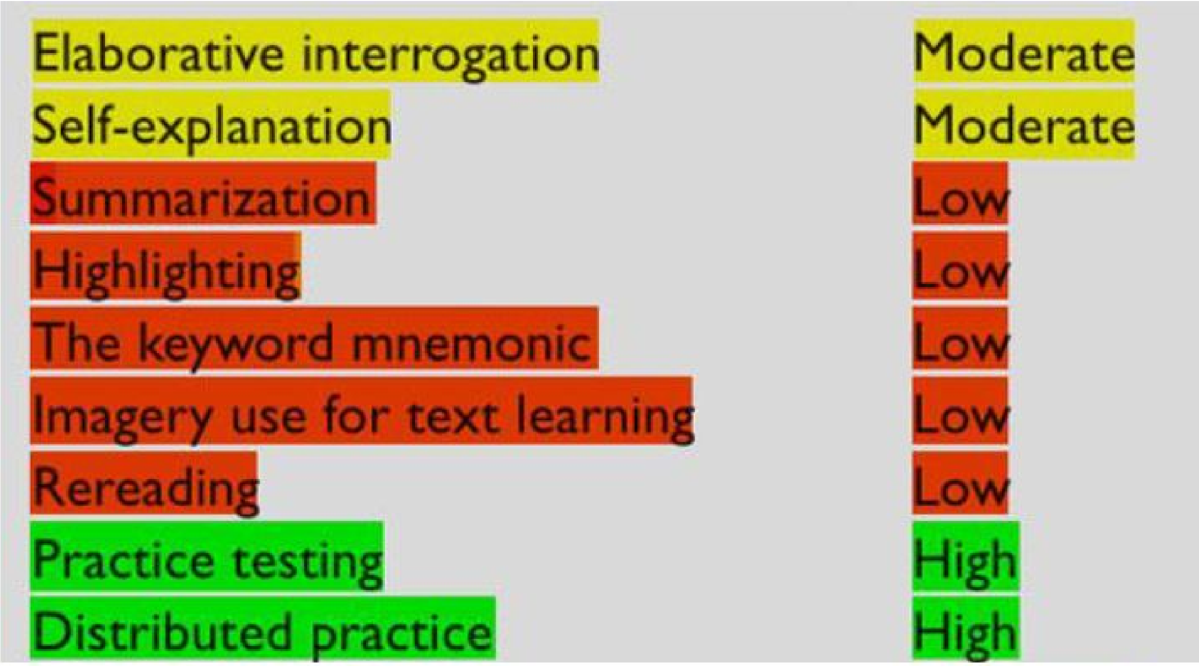
Extending the study period is beneficial

It’s the **robust effect**. According to a study by Cepeda et al. (2006), students recalled more after spaced study (47%) compared to massed study (37%). This may be caused by students being mislead into thinking they know the material better than they actually do when learning in bulk. The distributed practice also emulates the practice testing method, as the second learning episode will benefit from the consolidation of the first learning episode.

To remember something for a week, learning episodes should be 12-24 hours apart. For 5 years, they should be 6-12 months apart. Performance is best when the lag between sessions is around 10-20% of the desired retention interval.



RI = Retention Interval; ISI = Inter-Session Interval



Elaborative interrogation	Moderate
Self-explanation	Moderate
Summarization	Low
Highlighting	Low
The keyword mnemonic	Low
Imagery use for text learning	Low
Rereading	Low
Practice testing	High
Distributed practice	High

Recap of all different methods

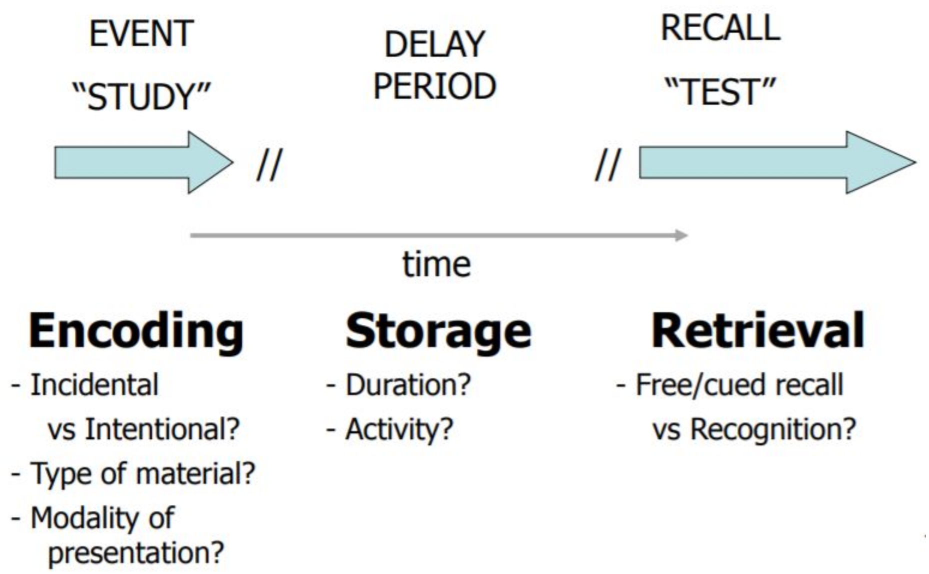
Reading:

Dunlosky, J., Rawson, K.A., Marsh, E.J., Nathan, M.J., and Willingham. D.T. (2013). "Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology."
Psychological Science in the Public Interest, 14(1), 4-58.

Memory I (Lecture 6): Multi-store Model

What is memory?

It's the process of **storing** information and experiences for possible future **retrieval**. When studying human memory, there are multiple things to consider, notably the process, storage, information/experience retained, and the possible future retrieval. All cognition requires memory.



Key terms in the stages of memory

Early Thoughts on the Multiple Memory Stores

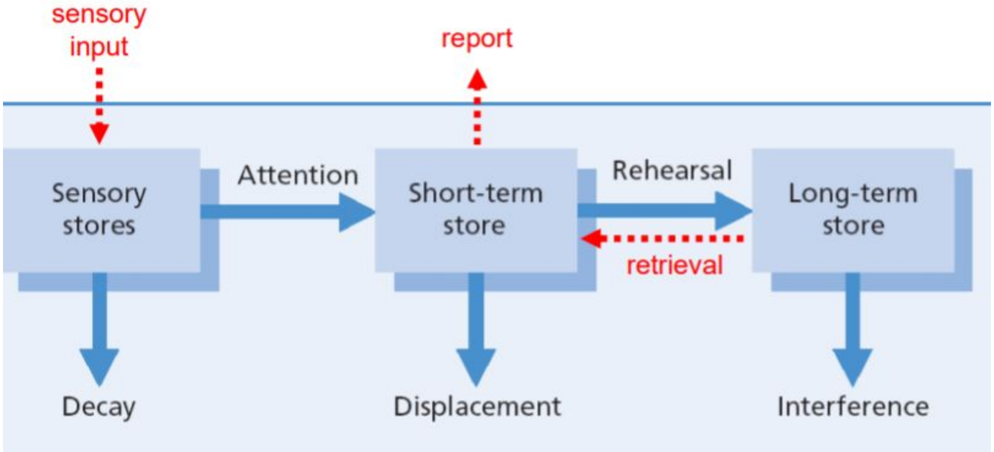
Memory has a limit and is not a monolith. The different models made on memory have evolved along time, and even the early ones distinguished between different types of memory.

William James (1890), made a distinction between **primary** and **secondary** memory:

- **Primary memory**: information that **remains in consciousness** after it has been perceived, forms part of the psychological present
- **Secondary memory**: information about events that have **left consciousness**, part of the psychological past

Hermann Ebbinghaus (1885/1913) performed hundreds of memory experiments on himself, discovering many methods and effects still important today, including the **capacity of short term memory** (7 +-2), **learning curve** and, most importantly, the **serial position curve** (this will be important later).

The **modal model** was coined by Atkinson & Shiffrin (1968). It's a **multi-store** model, and we'll study it out throughout the whole lecture:



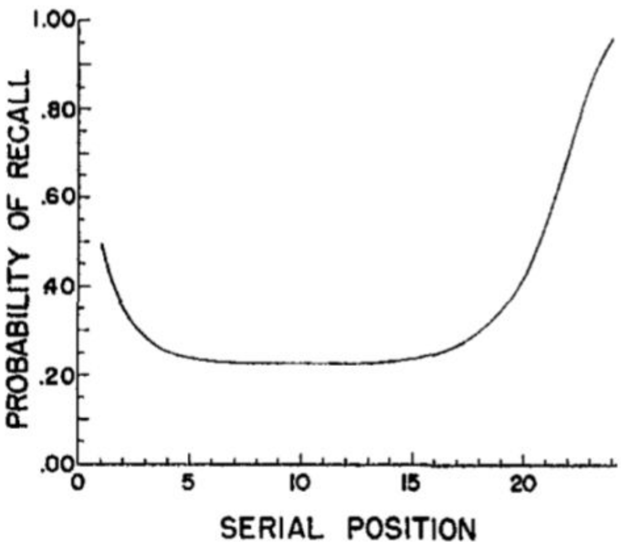
The modal model/multi-store model by Atkinson & Shiffrin (1968)

They reported that sensory stores were each limited to one sensory modality, and that the short-term store had a very limited capacity. On the other hand, the long-term store was essentially unlimited.

Distinctions between stores

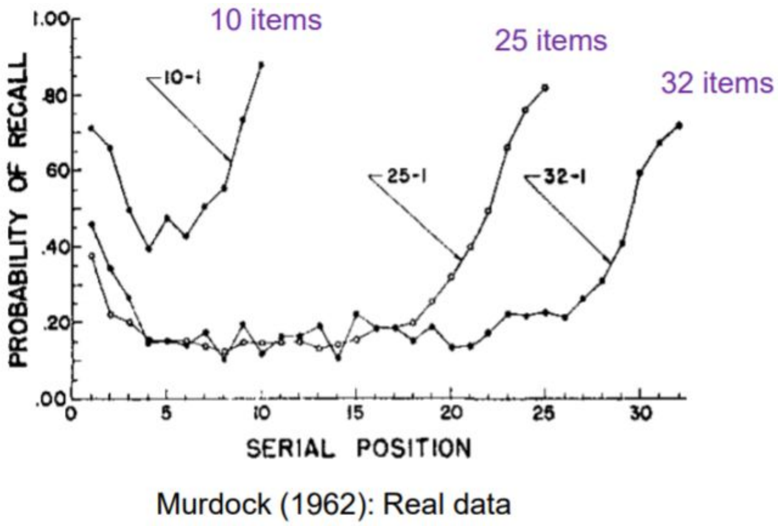
Short- vs. Long-Term stores (The Serial Position Curve)

If we conduct a free recall task (list of words/syllables presented at a fixed pace) and we plot the recall percentage plotted as a function of word's position in list, we'd ideally get something like this:



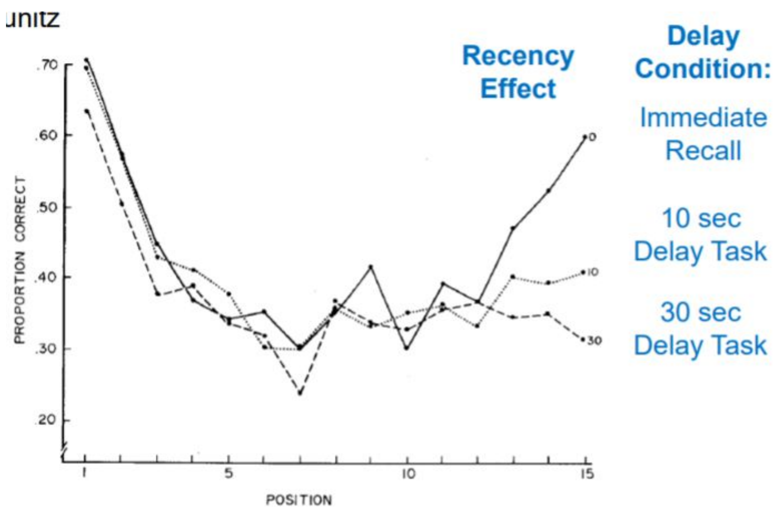
Serial position curve

This curve always has this form even with large amounts of items, the curve will decrease after the start to drastically increment at the end. This shape suggest there's multiple processes:



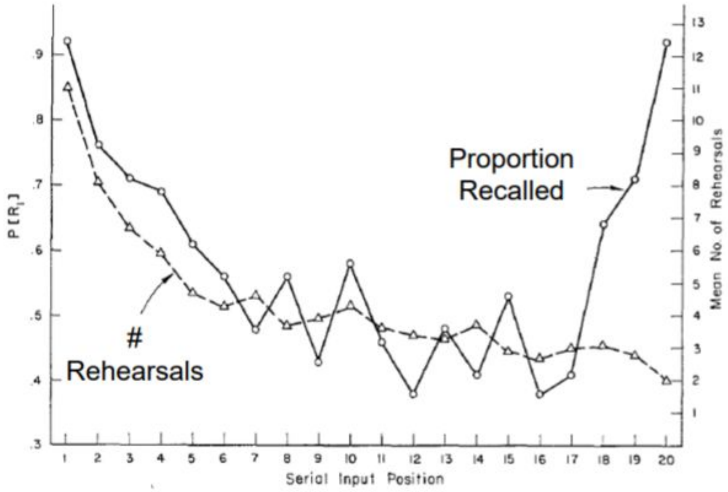
Fuck your amount of items

The **recency effect** could be an explanation for this increase at the end of the list, taking it from the short term store:



Glanzer & Cunitz (1966) displaying the effects of filled delay

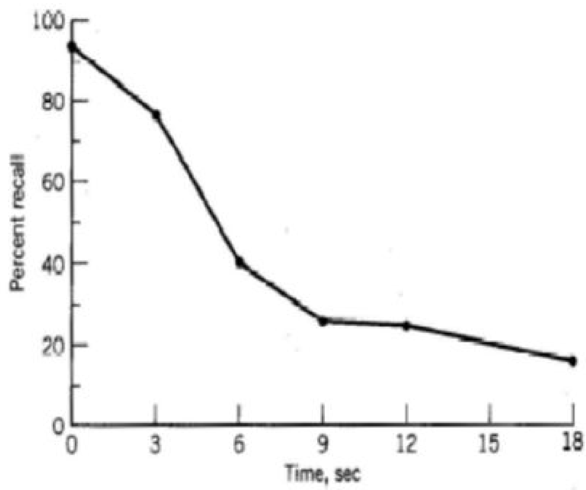
For the decrease at the start of the curve, we call this the **primacy effect**. This is caused as we tend to practice more the items at the start rather than those at the middle or end:



Rundus & Atkinson (1970) showing how the number of rehearsals is bigger for the items at the start

The serial processing curve is then affected by both the recency and primacy effect, which affects both the **short-term store** and the **long-term store**.

While the long-term store has a huge capacity (the record of Pi digit memorisation is 70,030 digits), aided by mnemonic strategies, the short-term store has an incredibly small capacity, this **magical number 7**. These mnemonic techniques don't work for the short-term store:



Brown-Peterson Paradigm showing short-term store duration

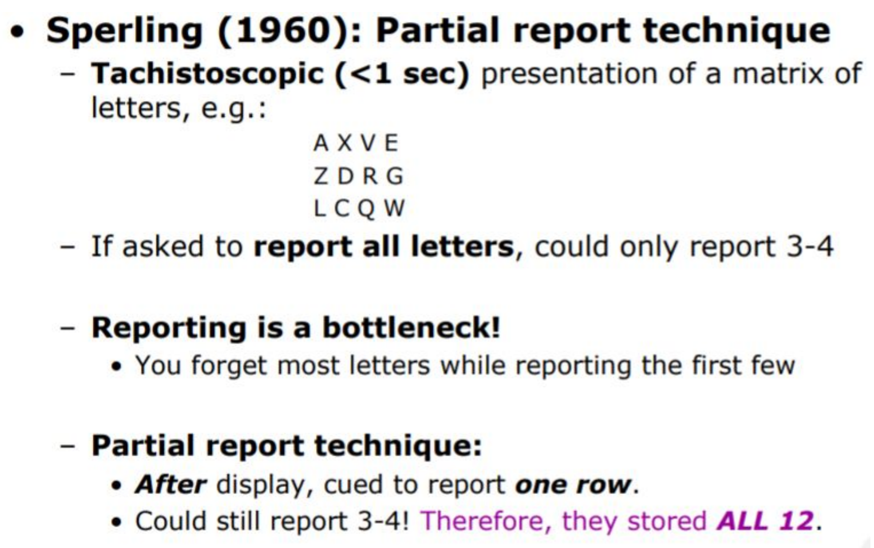
The graph above displays the results of the **Brown-Peterson Paradigm**, showing the percentage recall of nonsense trigrams (e.g. "WDL"), with the delay being counting backwards in 3s from a number (as this shouldn't interfere with letters). There's a **trace decay**, which is exponential over 20-30s.

It seems that the information in **short-term** store is done **phonologically**, as Conrad (1964, recall performance worse on similar sounding letters even if they were visually presented),

and Baddeley (1966, recall is worse if worse are phonologically similar, no effect of semantic similarity).
The capacity of the **long-term** store is difficult to evaluate, but it seems that it's **limitless**. It's also quite useful as we use it constantly. Indeed, language, social skills, motor skills, facts, and events are all stored in memory somewhere.

In long-term store, the information seems to be stored **semantically** (contrary to the short-term store). Baddeley (1966) also showed that recalling words after 20 minutes was poorer for semantically similar words (like "Great Big Huge Wide"). There was no effect of acoustic/phonological similarity.

Sensory store vs. Short-Term store (Partial report technique)



Short-term store is extremely difficult to investigate as it decays so quickly. However, it seems that the magical number 7 might not be as magical as we thought, as the reporting **hinders** the recalling, it's a bottleneck.

There is more reason to reject the number **seven** as the capacity of short-term memory. As **items** can be grouped into **chunks**, it's possible to store more than 7 items. If you were given, for example, "P S Y C L O G Y H O", you might realise that spells "psychology", and you'd be able to remember all 10 items.

The duration for which information is retained in the **sensory store** (first phase of the modal model) seems to vary depending on the way the information has been presented. If it's **iconic**, it will be around **500ms**; if it's **echoic**, it will be around **1-5s**. These types of sensory stores were presumed to be **preattentive**, meaning attention only occurs **after** information has been held in the sensory stores.

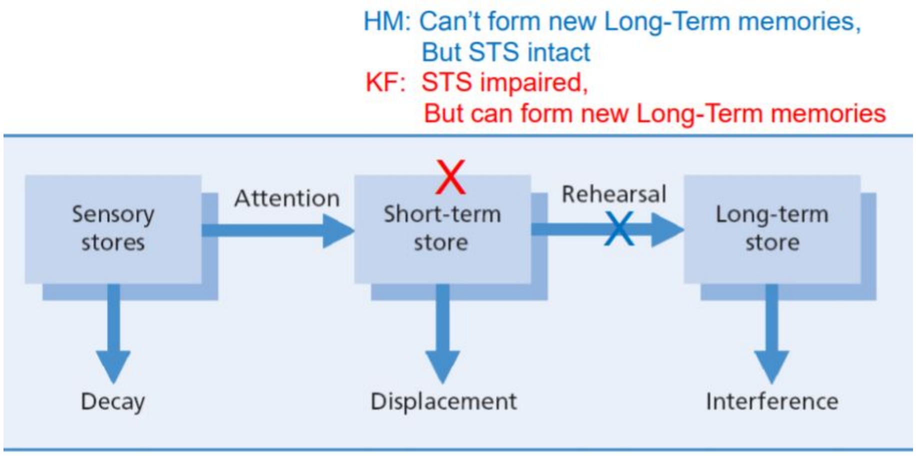
Neuropsychological evidence for dissociations

Neuropsychological evidence is the strongest evidence there is for multi-store models, coming from patients with **memory disorders**.

The most famous case is **HM** (Henry Molaison), a patient with **anterograde amnesia**: inability to make new long-term memory but intact short-term memory. He had this condition after a surgery to calm his intractable epileptic seizures in which the surgeon removed the **medial temporal lobes** (MLT) **bilaterally** (both). Normally only one was removed. Interestingly, there's **reduced primacy** but **intact recency**.

This patient was studied by Brenda Milner (Manchester-born), who was looking for hemispheric differences. She found that HM couldn't acquire new memories but could **acquire some skills**. However, he could vaguely remember important events that transpired after his surgery, like JFK's assassination, but without much detail. The memory from the past was intact, up to 3 years pre-surgery.

There are other patients with **impaired short-term store**. The patient **KF** had brain damage and normal long-term memory, but he had an impaired short-term memory, having a poor digit span.



Problem with the modal model

These two patients show shortcomings in the modal model. There's dissociations between both systems, but the model should not work

Problems with modal model

- **It's broken into mini-monoliths**. Subsequent research has shown that each of the stores is complex, and not a unitary, monolithic store

- **Short-term store does not seem to be the gateway to long-term memory**. If this was the case, then chunking items together while in short-term memory would not work, as chunking requires long-term memory to be accessed in order to retrieve the associations.

- **Emphasis on rehearsal**. Much unrehearsed information gets into LTS through implicit learning. If STS is the gateway to LTS, how come unconsciously processed information can get stored in LTS without rehearsal?

- **STS strictly phonological, LTS semantic**. There's non-verbal information too.

- **All items have equal importance**. This is an oversimplification, as there is also prioritization at such an early stage.

The stores are **oversimplified**. It's assumed they each always operate in a single, uniform way, when it doesn't seem to be this way.

Reading:

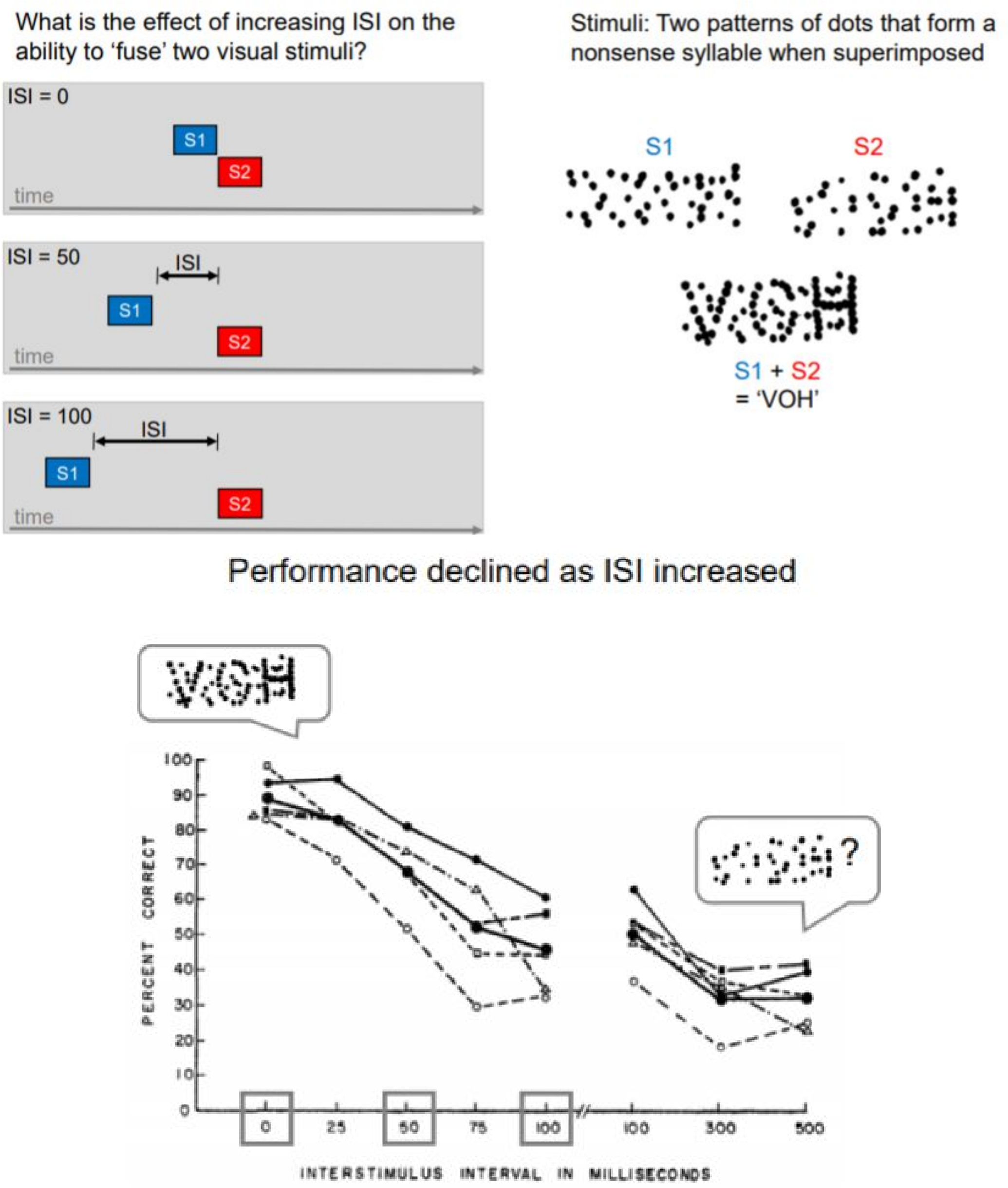
Eysenck & Keane (6th or 7th edition), chapters 6 & 7

Memory II (Lecture 7): Process Models of Memory

Visible Persistence (vs. Iconic Memory)

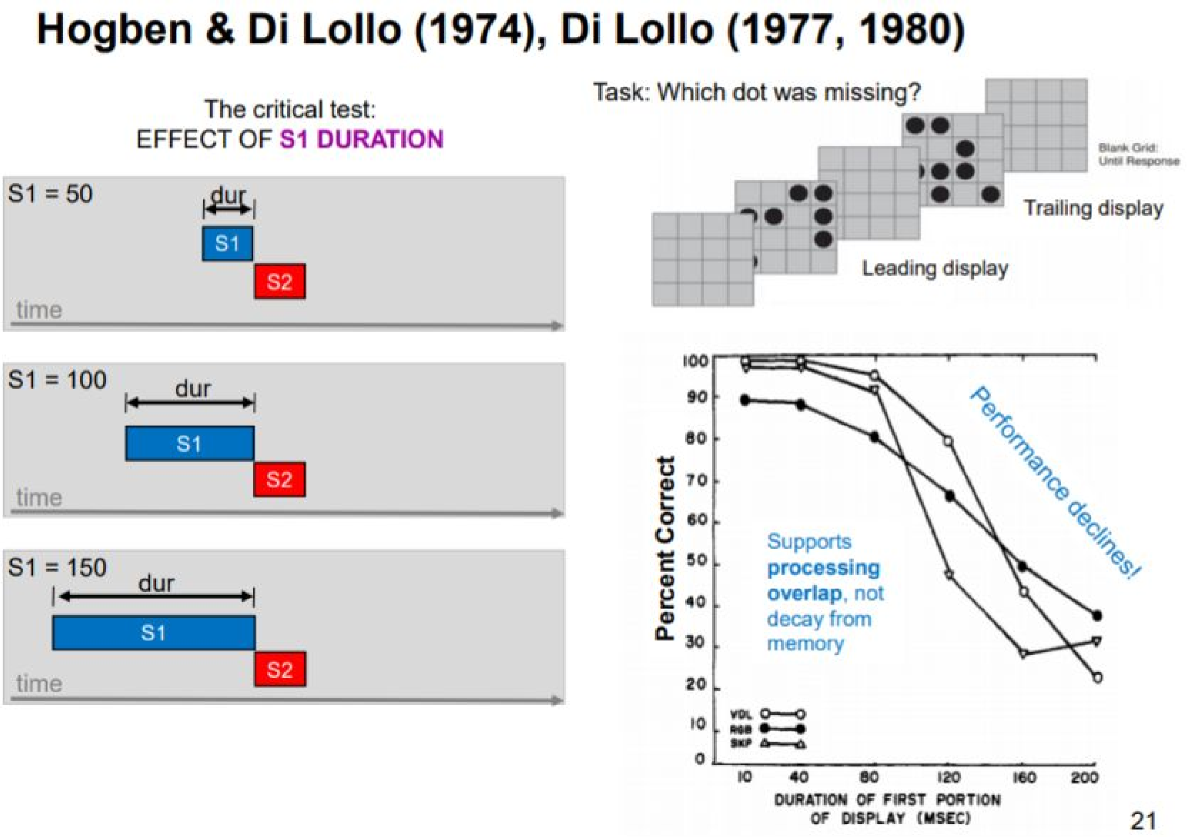
Visual Processing

Now we’re going to explore if these **sensory stores** would rather be a **sensory processing** phase. Visual “icon” is a memory store that decays rapidly in which images are analysed and interpreted. Eriksen & Collins (1967) shows that we can superimpose two differently display images if the delay between them is short, and extract the meaning of them, fusing them:



They interpreted these results as proof of memory store that decays rapidly. However, Di Lollo (1977) argued that this persistence of visual information was a phenomenon of **visual processing**. The results of Eriksen & Collins (1967) supported both theories.

They came up with a similar test in which they modified the durationtion for which stimulus 1 was presented, not the interstimulus interval (it remained nul).



Results supporting processing overlap over memory store

Their results supported that there was no memory store, as the interstimulus interval could be 0 but the performance declined the longer that first stimulus was displayed for.

Three separate phenomena?

Coltheart (1980) had a big heart and proposed a theory that validated both theories, supporting **three different phenomena**:

- **Neural persistence**: overlap in neural processing, very brief
- **Visible persistence**: overlap in visual processing (Di Lollo), <200 msec
- **Informational persistence**: icon that decays (Sperling), ~ 150-300 msec

Why bother?

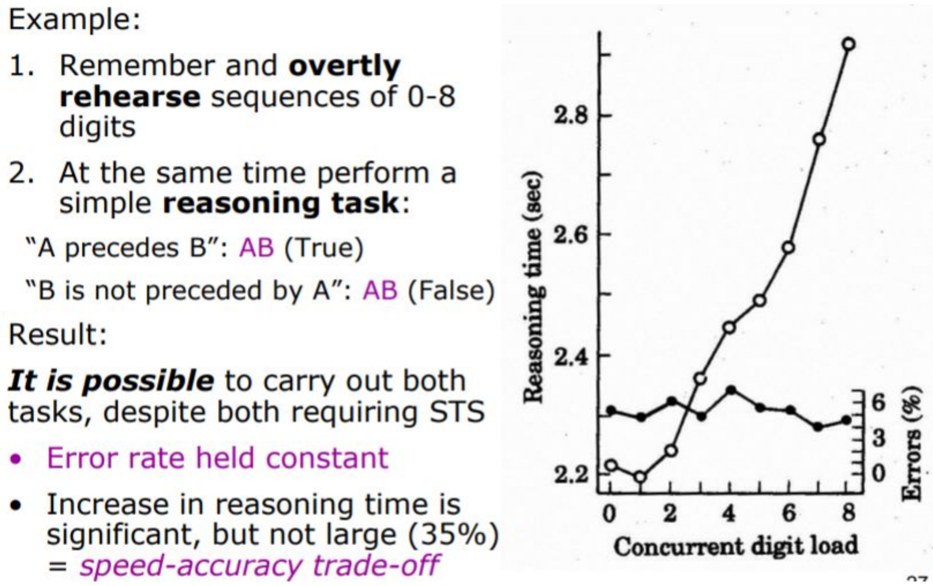
Haber (1983) said that these studies had no ecological validity.

“The notion of an icon as a brief storage of information persisting after stimulus termination **cannot possibly be useful** in any typical visual information-processing task **except reading in a lightning storm**.”

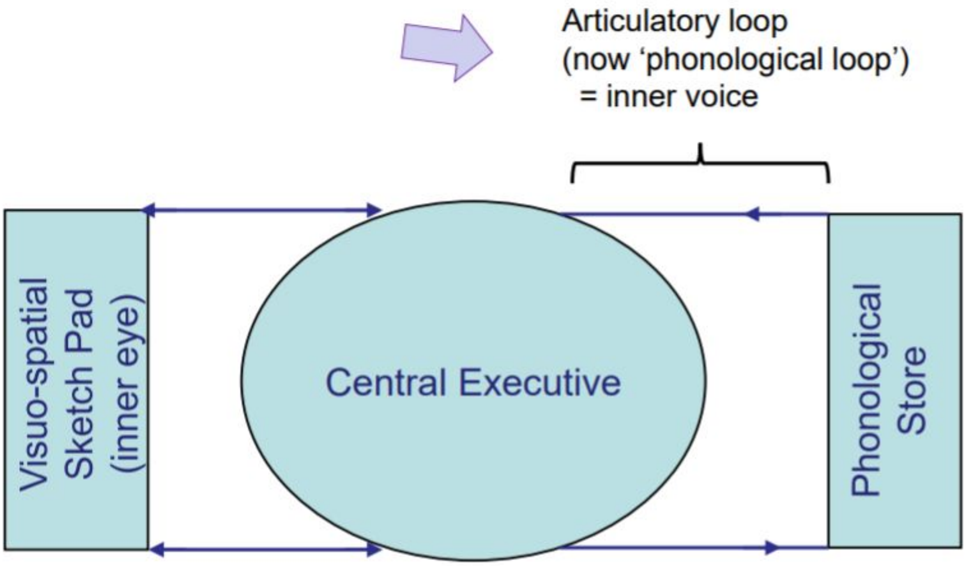
Working Memory (vs. Short-Term Store)

Motivation for the Working Memory Model

Baddeley & Hitch developed **dual task paradigms**. They made participants perform a **primary task** whilst simultaneously performing a **secondary task** presumed to take up short-term store capacity. **Overt rehearsal** of secondary task ensures that you are not switching between tasks.



After these results, they proposed the **working memory model**:



It has three main different parts:

- **Central executive**: an attentional system, with limited capacity. It deals with any cognitively demanding task. It works with and coordinates the phonological loop and the visual-spatial sketchpad.

- **Phonological loop**: processing and storing information briefly in a phonological form.

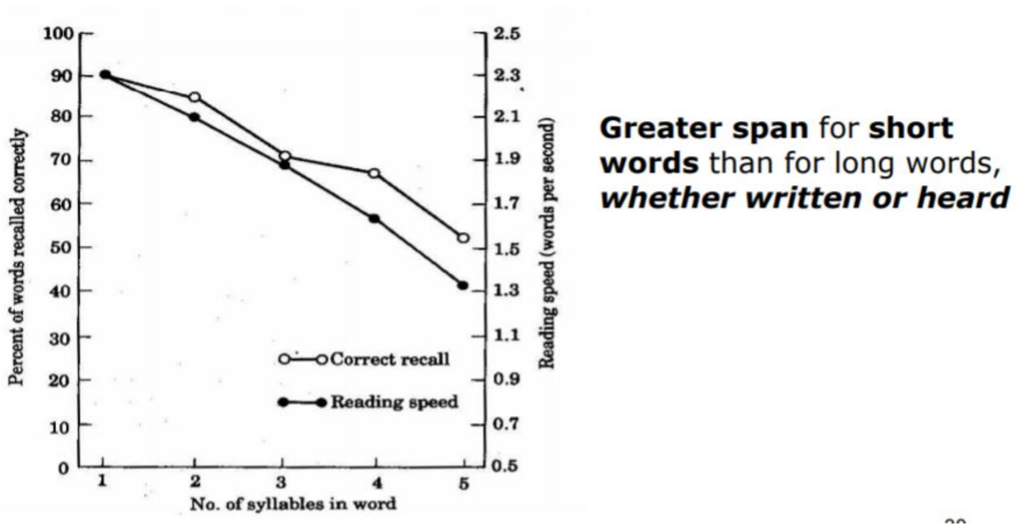
- **Visual-spatial sketchpad**: specialised for spatial and visual processing and temporary storage.

This model assumes that if two tasks use the **same component**, they **can't** be successfully performed together. On the other hand, if they use **different components**, it should be possible to perform them as well **together as separately**.

Evidence for the Working Memory Model

There's the **phonological confusability effect** ("PGVCE" harder to recall than "XRFYZ").

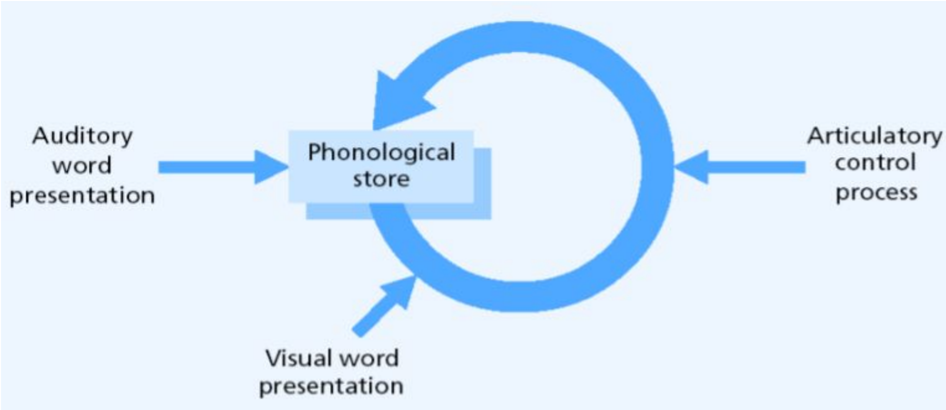
There's also the **word-length effect** (Baddeley 1975):



Word-length effect

These are evidence for a speech-based phonological system with two components:

- **Phonological store**: holds memory traces for a few seconds before they fade
- **Articulatory (/Phonological) Loop**: rehearsal process analogous to subvocal speech (inner voice)



Phonological loop model

Revisions for the Working Memory Model

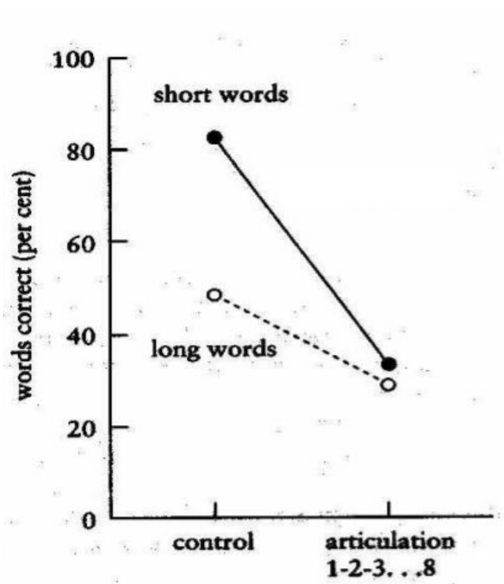
Instead of the syllable number, it seems that **spoken duration** is crucial. Memory spans are **greater for short-duration** words than for long-duration words, **even if they have the same number of syllables**.

The digit span also varies depending on the **language** because of this spoken duration effect:

Language	*Articulation Rate*	*Digit Span*
Chinese	265 ms/digit	9.9
English	321 ms/digit	6.6
Welsh	385 ms/digit	5.8

(Hoosain & Salili, 1988; Ellis & Hennelly, 1980)

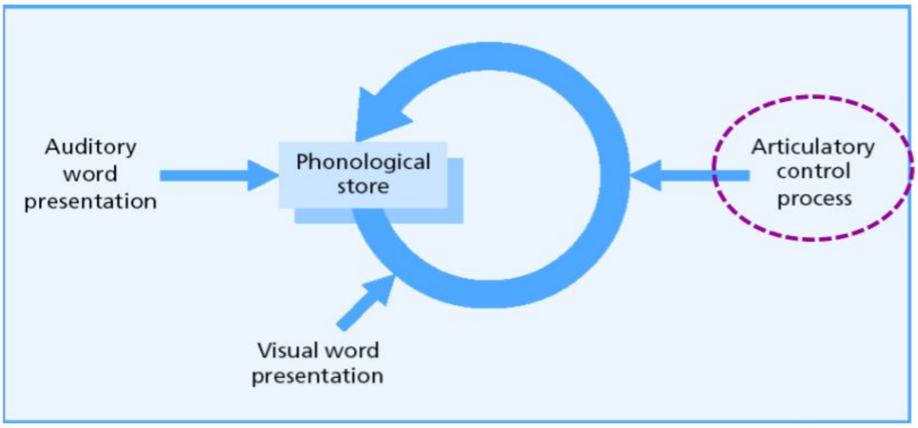
There's also **articulatory suppression**:



What happens if you prevent material being articulated?

- **Articulate irrelevant items** (overtly or covertly) while performing a **verbal span task**
- Result: **word length effect disappears** (for **written words** only!)
- Explanation:
  - Articulation of irrelevant items ***dominates* Articulatory Control Processes**, so **words cannot be rehearsed** - word length has no influence
  - But spoken words go straight to phonological store

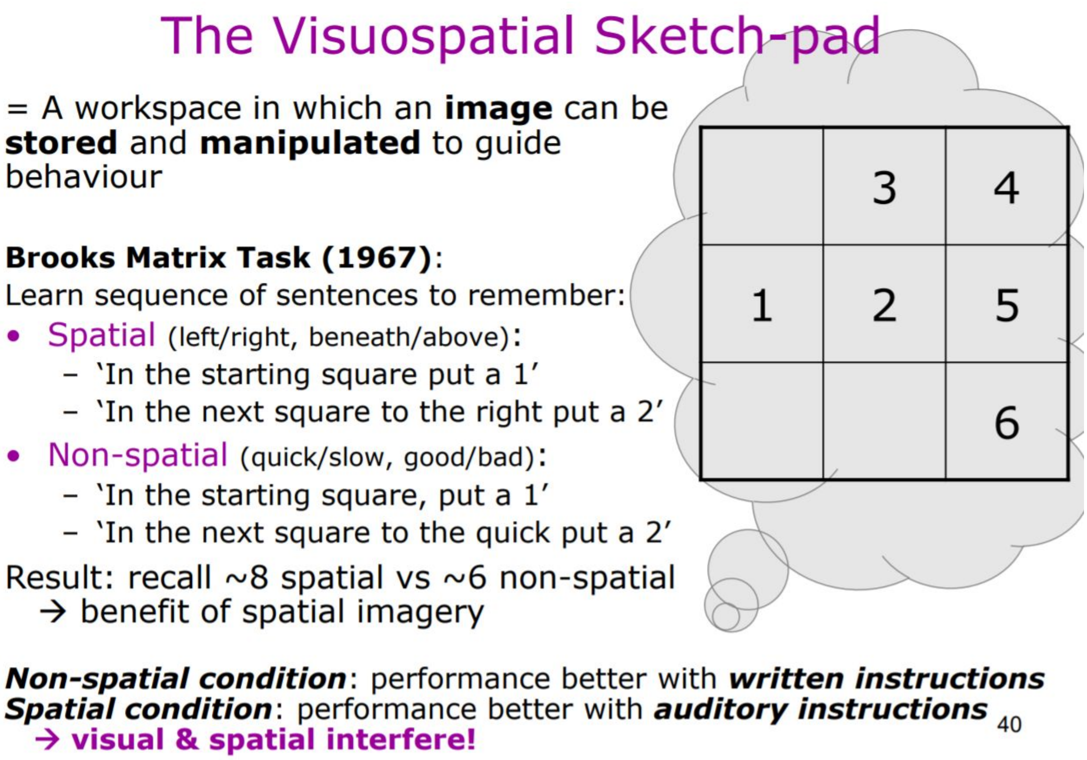
All of this suggests another version of the phonological loop, in which an **articulatory control process** has an influence too:



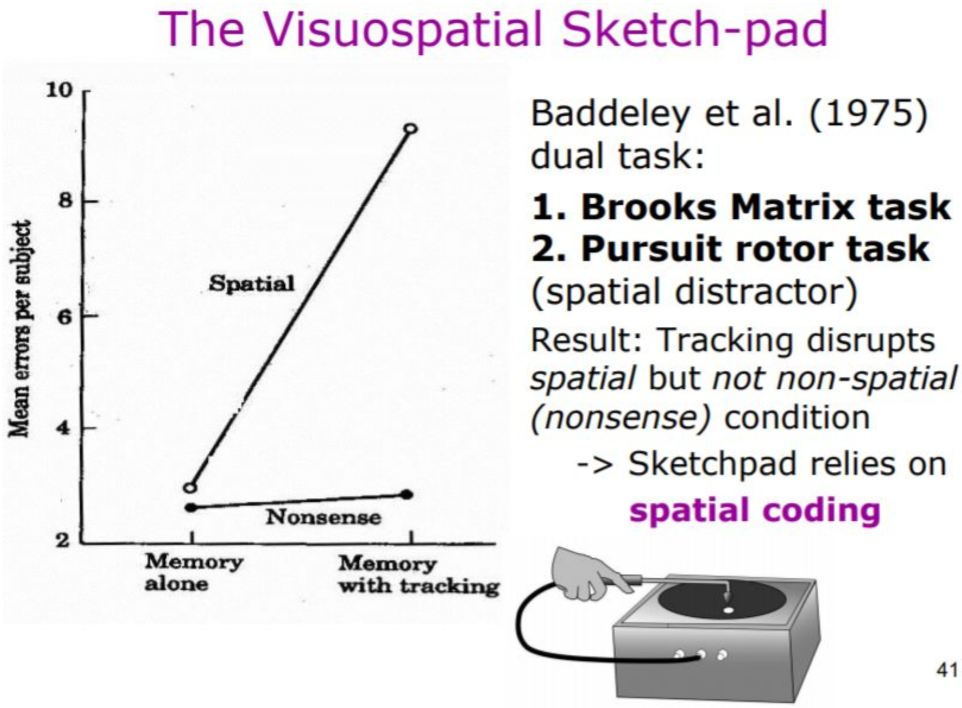
The **phonological loop** is for:

- **Learning to read**: lower memory spans → reduced reading ability
- **Vocabulary acquisition**: correlation between non-word repetition ability and vocabulary size
- **Language comprehension**: STS patients have difficulty comprehending complex sentences (longer with more adjectives and adverbs)

The **visuospatial sketch-pad** is also interesting, also called the **inner eye**. This is a workspace in which an image can be formed, stored, and manipulated to guide behaviour:



Baddeley checked if **dual tasks** were disrupted if both tasks were spatial:



The **sketchpad** is for:

- **Geographical location**: learning our way around our environment
- **Spatial tasks**: planning and performing

It's been suggested that this **sketchpad** consists of two components:

- **Visual cache**: stores information about visual form and colour
- **Inner scribe**: processes spatial and movement information. Involved in the rehearsal of information in the visual cache and transfers information from the visual cache to the central executive.

The **central executive** is the most complex and least understood component of working memory (it's also quite controversial cause it seems like a black box system). It works more as an **attentional system** rather than a memory store, coordinating the activity of the sketchpad and the phonological loop.

Years after the original model was proposed, it was revised to add an **episodic buffer**. In its original form, the different components in the model were too separate in their functioning. One of the main functions of this buffer is to provide **storage** for verbal, visual and spatial information.

Problems with the Working Memory Model

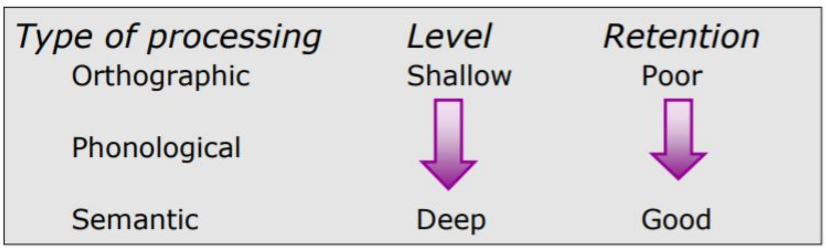
- **Articulatory suppression**: doesn't fully prevent registration of visually presented words which should be recoded phonologically
- **Neuropsychological data**: STM patients, visual and verbal spans are similarly affected (Baddeley et al., 1997 showed digit span of 2, visual span of 4)
- **Rehearsal**: How is non-verbal visual information rehearsed? How do pre-verbal children rehearse verbal information?
- **Consciousness**: How can consciousness bind information from different modalities without a multimodal short term store? (see "Episodic Buffer", Baddeley, 2000, NOT IN THE EXAM IT SEEMS)
- **Other senses**: what about olfactory, tactile and gustatory information? They are not considered in this model

Levels of Processing (vs. 'Rehearsal' in LTM)

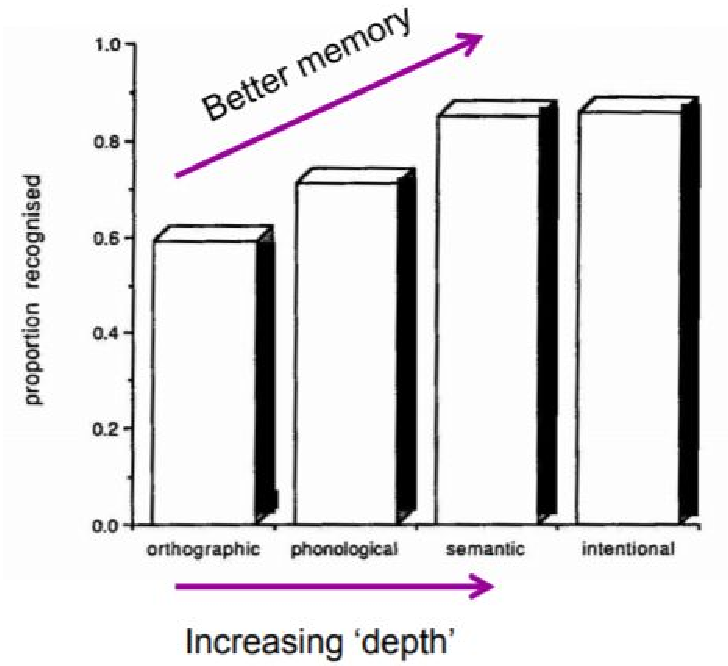
Motivation for the framework

Craik & Lockhart (1972) challenged assumptions of modal model, that memory involves items being held in structural stores, that the fate of items is determined by property of store, and that all types of rehearsal are equally effective. They argued that:

- A **memory trace** consists of a **record of those processes** carried out for the purposes of perceptions
- The **deeper** the processing, the **better the retention**
- **Short-term memory** is just really a **temporary activation of long-term memory**



Evidence from incidental learning paradigms supported the idea that **encoding can occur without rehearsal**: subjects were **unaware** that their memory would be tested, and **weren't intentionally encoding** or rehearsing. What **processes** were active then, and how does it affect retention? Craig (1977) showed that deeper dept, and hence deeper processing, was linked with better memory:



They also distinguished between different types of rehearsal:

- **Type I** - Maintenance rehearsal
- **Type II** - Elaborative rehearsal

Only **type II** rehearsal is associated with **increased** retention.

Evidence

Svenson (1977) classified students according to how they read a piece of text, a **surface approach** ("try to memorise everything"), and a **deep approach** ("try to identify the principal ideas"). Those who adopted the deep approach recalled substantially more in an unexpected recall test. It also showed in the amount of students that passed the course (9/10 for deep, 3/13 for shallow).

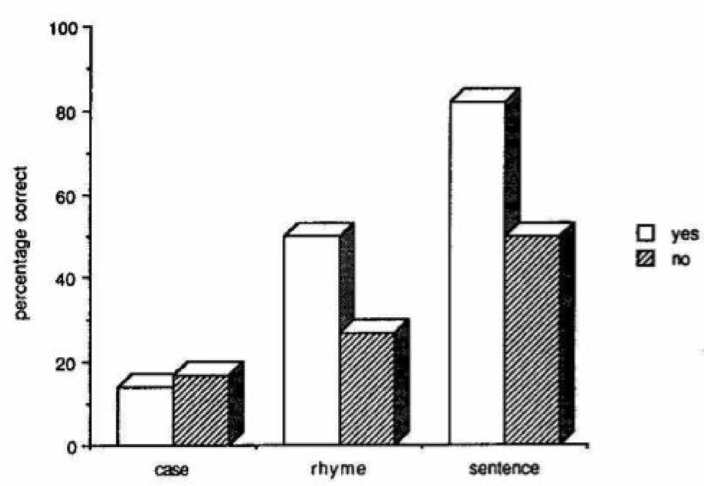
Developments

The **elaboration effect** shows that high elaboration led to better retention. It could be that elaborate processing increases the number of associations between stimulus and context:

> Q. Could the word 'watch' fit into the following sentence?
>
> She dropped her ____ .
>
> [*low elaboration*]
>
> The old man hobbled across the room and dropped his _____ in the jug.
>
> [*high elaboration*]

Example of low vs. high elaboration

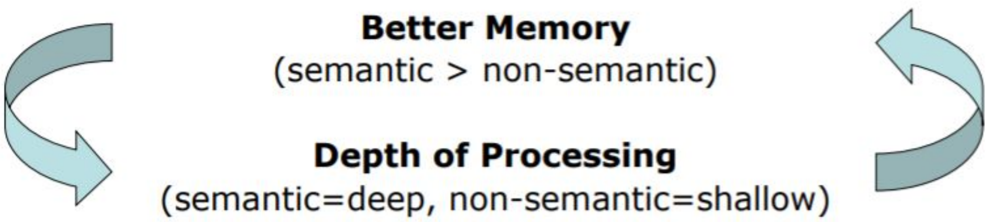
The **congruency** effect shows better performance when the initial orienting task evokes a **yes** response. This is also known as the **compatibility effect**. It's exaggerated by deeper processing tasks:



Congruency effect

Problems

One of the main problems is **circularity**:



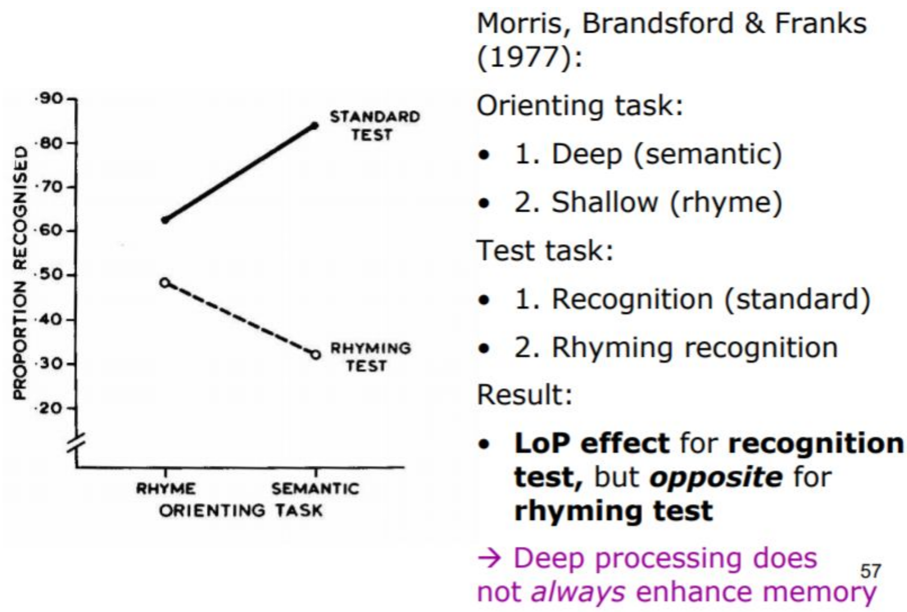
To break this, an **independent measure of depth** is required.

Other problems are:

- **Weak theoretical** power, it's more of a framework than a theory
- Used concepts like **elaboration** and **compatibility** are equally as **slippery** as **depth**

- Shallow orienting tasks almost certainly involve some **automatic semantic processing** (name colour of the ink in words: **red** **green** **yellow** **blue**)

- **DEEP PROCESSING DOES NOT ALWAYS ENHANCE MEMORY** according to Morris, Brandsford & Franks (1977):



Results of Morris, Brandsford & Franks (1977)

They came up with **Transfer-Appropriate Processing (TAP)** to explain this. Memory performance depends on the extent to which processes used at the time of learning are the same as those used when memory is tested. The TAP approach demonstrates that a form of encoding which is “shallow” for one purpose may be “deep” for another.

Craik & Lockhart assessed the impact of the LoP approach in 1990, admitting that they were **wrong** on several counts, accepting the notion of **TAP**. Shallow processing does **not always** lead to rapid forgetting, and processing does **not** necessarily proceed from **shallow to deep**. They pointed out that LoP was presented as a **framework** and not a theory, and that many of its criticisms were addressed in later versions of the model.

Reading:

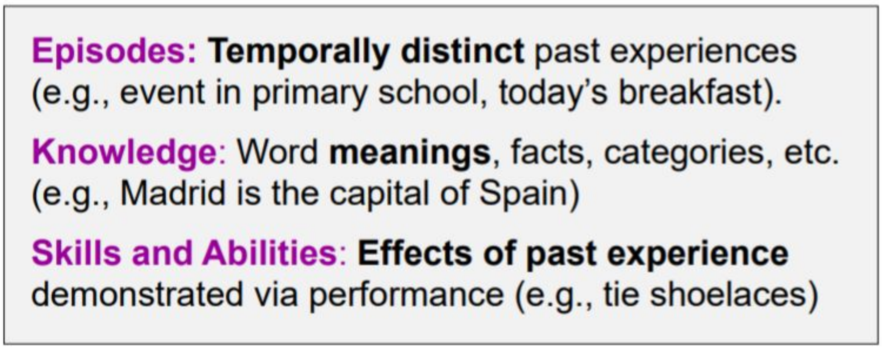
Eysenck & Keane (6th or 7th edition), chapters 6 & 7

Memory III (Lecture 8): Remembering & Forgetting

Remembering

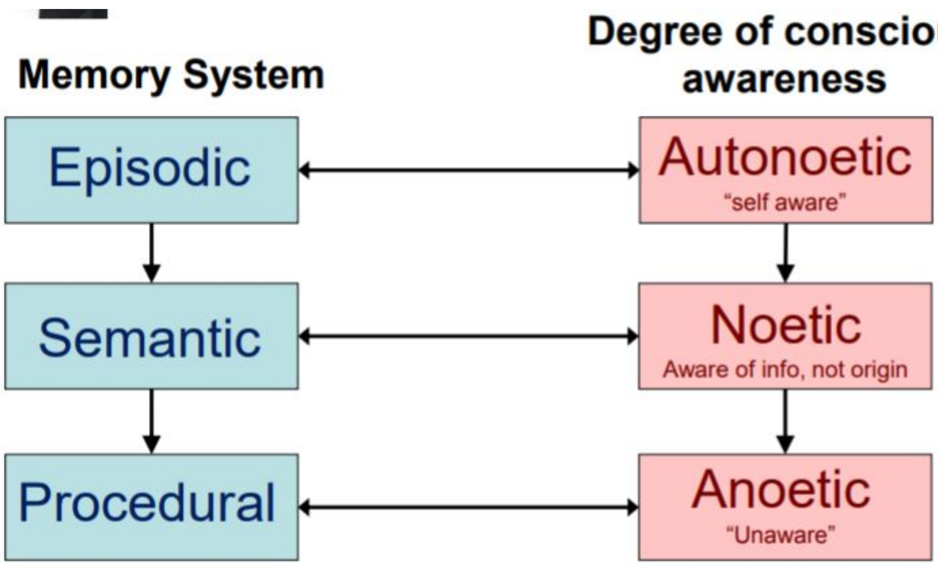
Background

Is LTS a **unitary store** that contains different types of information, or are there **different LTM systems**? There are different types of information that we're able to store long-term:



Different types of information

Tulving (1985) proposed a model in which there were different systems and types of memory:



Tulving's (1985) Model

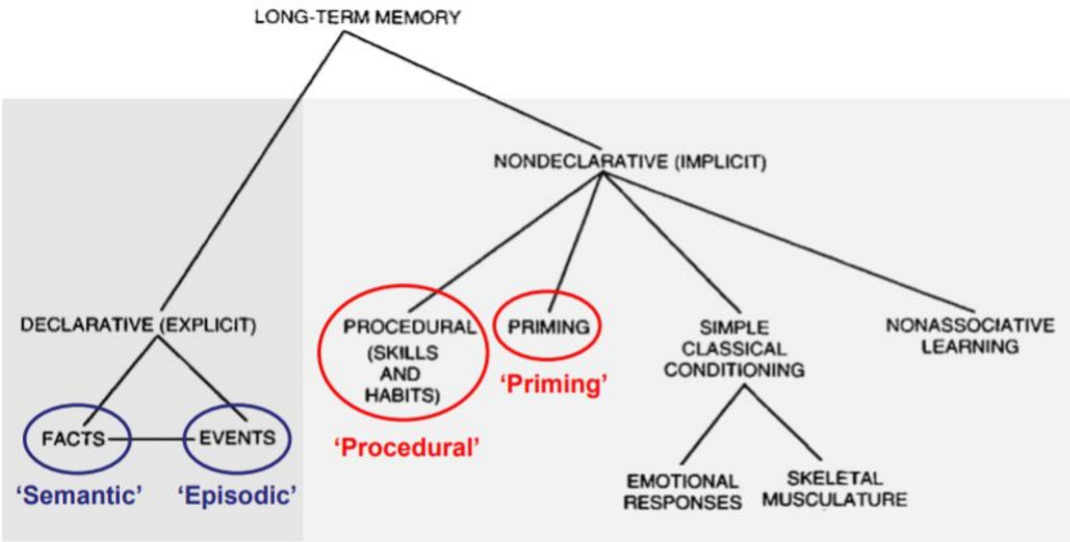
According to him, all three memory types are **interactive**. Learning the meaning of a new word originally requires an episodic memory, and over time the meaning becomes assimilated into semantic memory, and the original learning episode may be forgotten. In the case of procedural memories, one can't even describe how one knows, one just knows. The ability to **disconnect information** was linked to freeing up storage space.

He distinguished between memory **systems** and **tests**:

- **Episodic or Direct Test**: e.g. recognition memory for previously presented words, intended to measure the episodic memory system
- **Episodic Memory System**: i.e. conscious retrieval of past episode

But it's **more complicated than one-to-one mapping**, as some episodic tests can be influenced by non-episodic memory systems.

Contemporary Model of LTM Systems



Squire & Zola Morgan (1991); Squire (2004) Taxonomy of LTM

In this Squire & Zola Morgan (1991) model of LTM, there are two set of systems of long-term memory. One is **declarative/explicit**, formed by events you can remember, and **nondeclarative/implicit**, which is procedural. These are some of the more important systems:

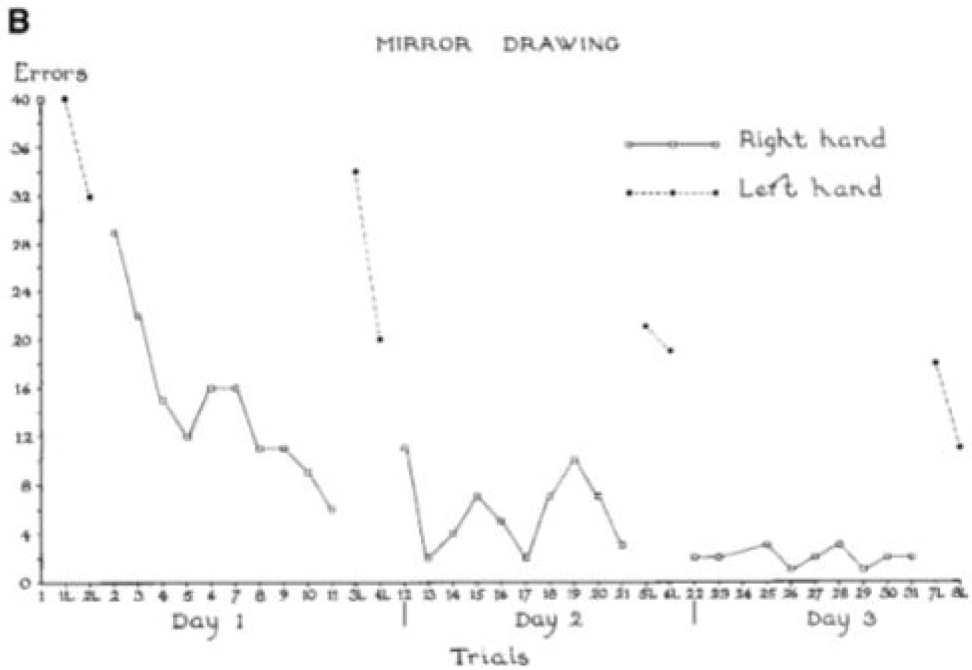
- **Semantic memory** (declarative) is general knowledge of objects, word meanings, facts, people and other stuff **without connection** to a specific time and place. It's also called **generic memory**

- **Episodic memory** (declarative) is memory for events and experiences **tied to a specific time and place**. Free recall, cued recall and recognition tests touch on episodic memory

- **Procedural memory** (nondeclarative) is knowledge of how to do things, **skills**. IT's acquired through multiple trials, and is largely **preserved in amnesia**. HM, despite not being able to create new memories, he was able to acquire new skills, showing a difference between these LTM systems.

- **Priming** (nondeclarative) is the **improvement** in **processing** a stimulus as a result of a prior encounter with the same or a related stimulus. This can happen without realising you've encountered a previous stimulus.

Characterising and Dissociating LTM systems (Explicit vs. Implicit Memory)

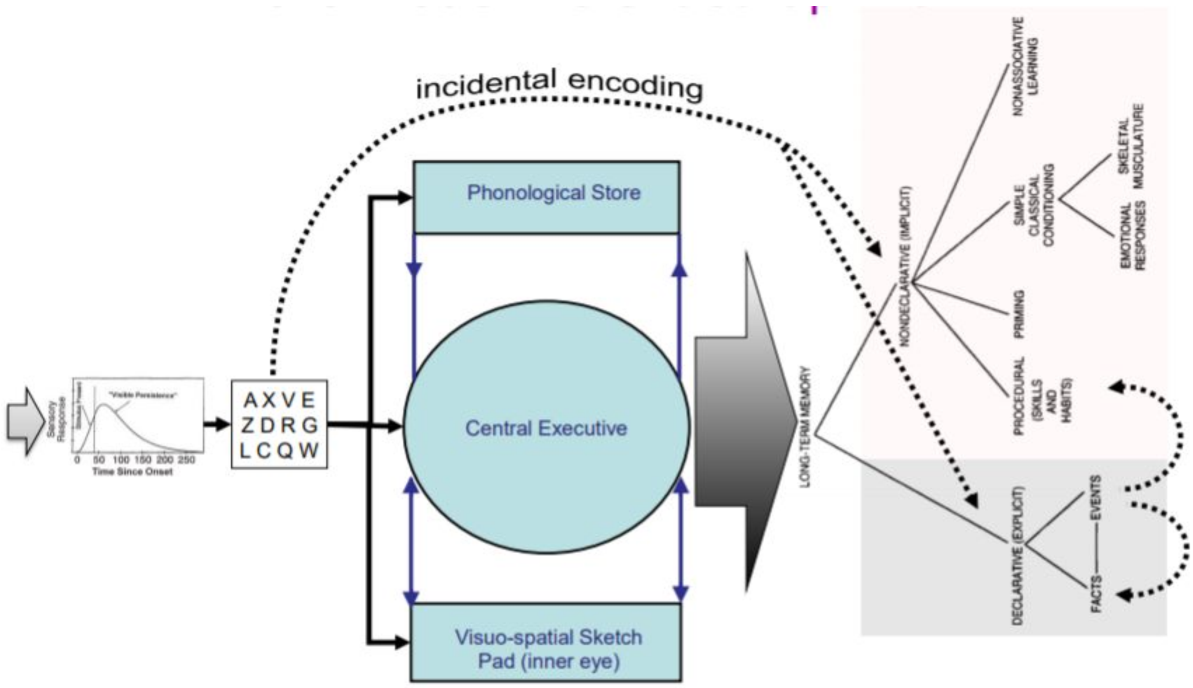


HM's progression in mirror drawing

As we discussed before, **amnesic patients** can learn to perform 'procedural' tasks despite complete lack of (episodic) memory for training (Milner, 1962: H.M. 'mirror drawing'). They show **intact perceptual priming** (perform better under incidental instructions in recognition memory tests: "first word that comes to mind").

On the other hand, patients with **right occipital lobe lesions** (patient MS, Gabrieli et al. 1995) show **normal declarative memory** (recall, cued recall, recognition) but **impaired perceptual priming**.

The model we've ended up with is this:



Complete memory model. Nobody shows it like this, too much

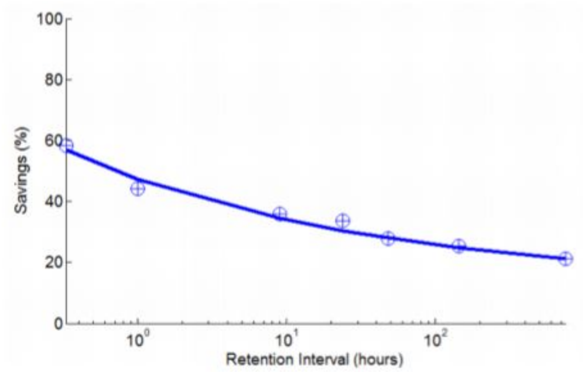
Why do we forget?

Interference (vs. Decay)

Is all forgetting just **retrieval failure**? Patient AJ is called as the **woman who never forgets**, as she's able to recall anything autobiographical it seems. It should be noted, however, that she keeps a very detailed journal on everything that had happened to her each day, and that while her memory might be impressive, it might be aided by this journal keeping.

This seems to point that **retrieval is a complex process**, as many seemingly forgotten memories can be retrieved if in the correct setting. For example, Penfield (1958) argued that stimulating the temporal lobes of patients often elicited trivial "memories", and hence that the brain retains a permanent record of all experiences.

Ebbinghaus (1885) learned 169 separate lists of nonsense syllables, relearning each list after an interval of 21 minutes to 31 days, with the time required to relearn the list as the measure of forgetting. He obtained the following formula and **forgetting curve**:

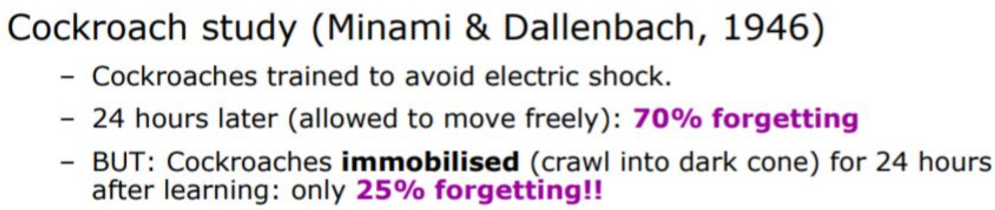


y = 1.84./((log(t)).^1.25 + 1.84)

The Forgetting Curve

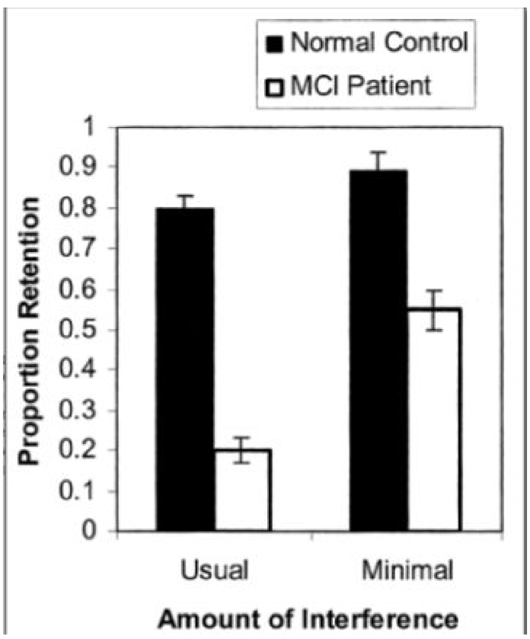
There were two early hypotheses on forgetting:

- **Decay**: memory simply fades with **time**
- **Interference**: memory traces **disrupted** or **replaced** by subsequent/prior learning



Study on interference

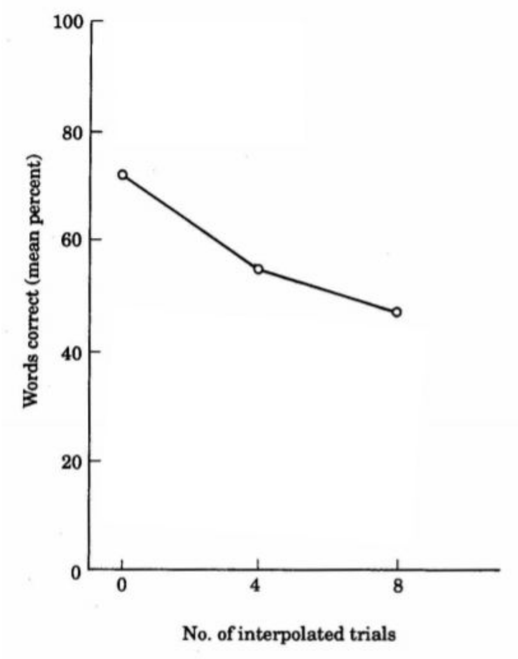
With humans, this seems to also work. Patients with a white bar had alzheimer's, and put in a dark room to minimise interference:



Seems to work on humans too...

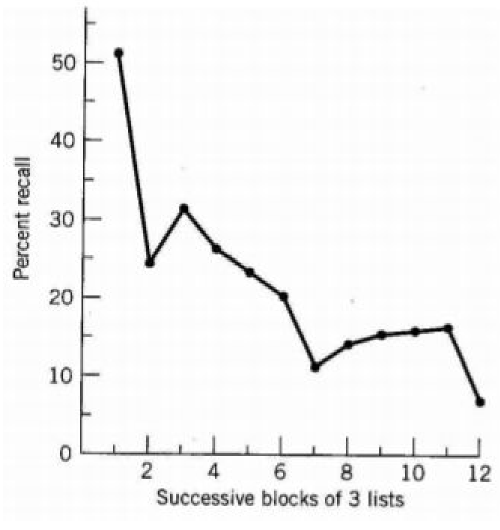
More research has been done, and there are two main types of **interference**:

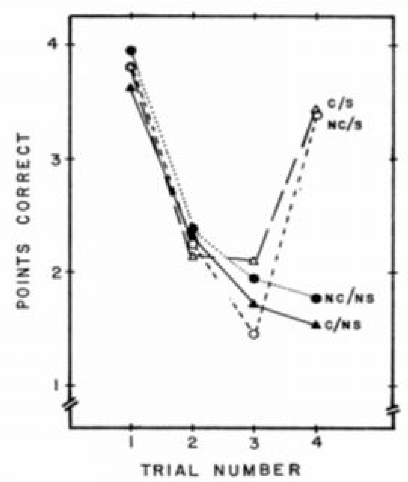
- **Retroactive interference**: later learning disrupts earlier learning. Slamecka (1980) had students read sentences 8 times followed by rest or 4 or 8 trials of equivalent sentences, having to retrieve original sentences:



Slamecka (1980) results displaying retroactive interference

- **Proactive interference:** prior learning disrupts subsequent learning. Underwood & Keppel (1962) shows performance declines over successive study-tests with similar stimuli. Performance recovers when switching to dissimilar stimuli:





Release from PI: (Wickens, 1970; MacLeod, 1975):

When **category changed** after interference builds up, **performance jumps!**

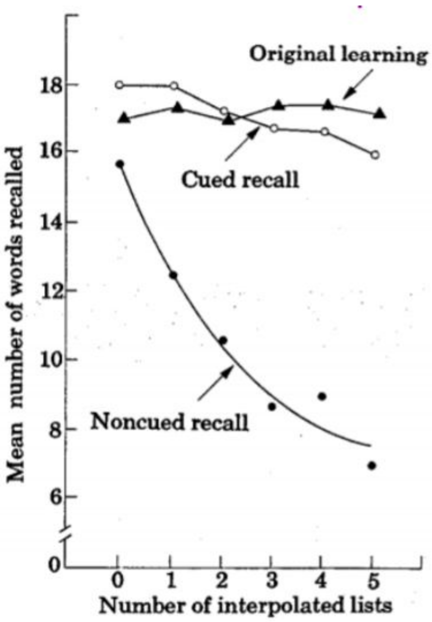
Underwood & Keppel (1962) results showing proactive interference

Proactive interference seems to be caused by **competition** between the correct response and one or more incorrect one. There's more competition when the incorrect response or responses, previously stored in memory, are associated with the same stimulus as the correct response.

Cue-dependent Forgetting

Cue-dependent forgetting was pushed by Tulving (1974), arguing that the **failure of retrieval** led to forgetting. Free retrieval is more difficult than **cue-dependent** retrieval, and retroactive interference is weaker with cueing.

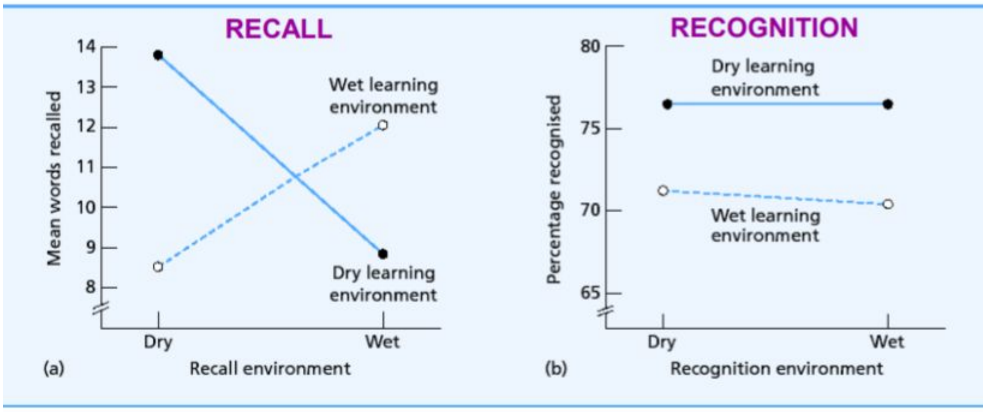
Tulving & Psotka (1971) showed that cued recall is not affected by retroactive interference:



Results of Tulving & Psotka (1971)

Following this, he pushed the **encoding-specificity principle** (Tulving, 1979), suggesting that retrieval success depends on **information overlap** between encoding and retrieval. It's similar to **transfer-appropriate processing**, but hinges more about **context** rather than processing. That context can be in two ways:

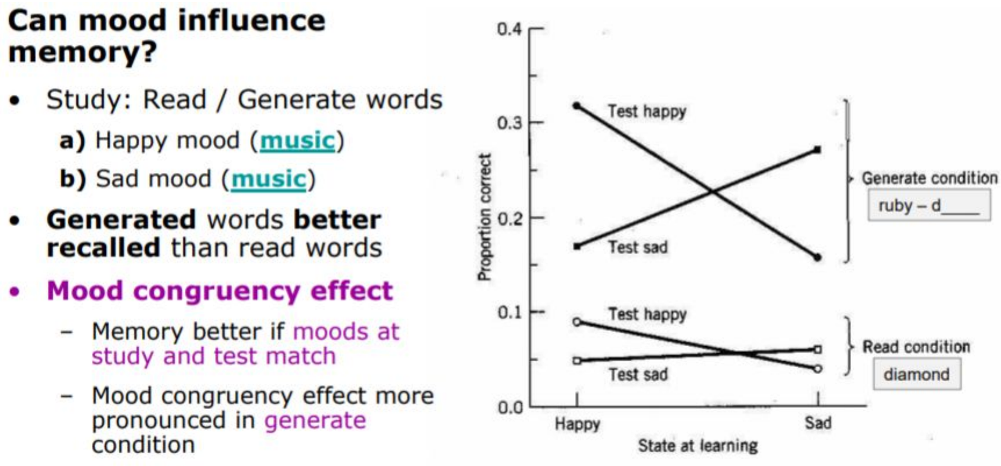
- **Intrinsic context**: features that are an integral part of target stimulus
- **Extrinsic context**: other features present at the time of encoding (time, place, cognitive state)



-> Memory performance better if study & test *extrinsic* contexts were matched
* But only for free recall! (recognition has strong intrinsic cues)

Godden & Baddeley (1975) shows a match between study and test context

Mood while learning has also been studied:



Repression & Motivated Forgetting

Freud (1901) said that people actively prepress unpleasant memories. Actual rational people then came along, and Levinger & Clark (1961) showed that students remember fewer negative associations than neutral ones. On the other hand, Parkin et al (1982) repeated the study adding a 1 week delay, having **emotional associations better remembered**.

Furthermore, Williams (1994) showed that those who suffered more abuse are most likely to remember.

Mike Anderson's Think/No-think paradigm: simply **directing people to** previously learned associations can **reduce later cued recall** for those associations.

Consolidation

Consolidation (by Dudai, 2004) is a physiological basis of memory, fixing information in long-term memory, strengthening connections between brain regions over hours, days, months…

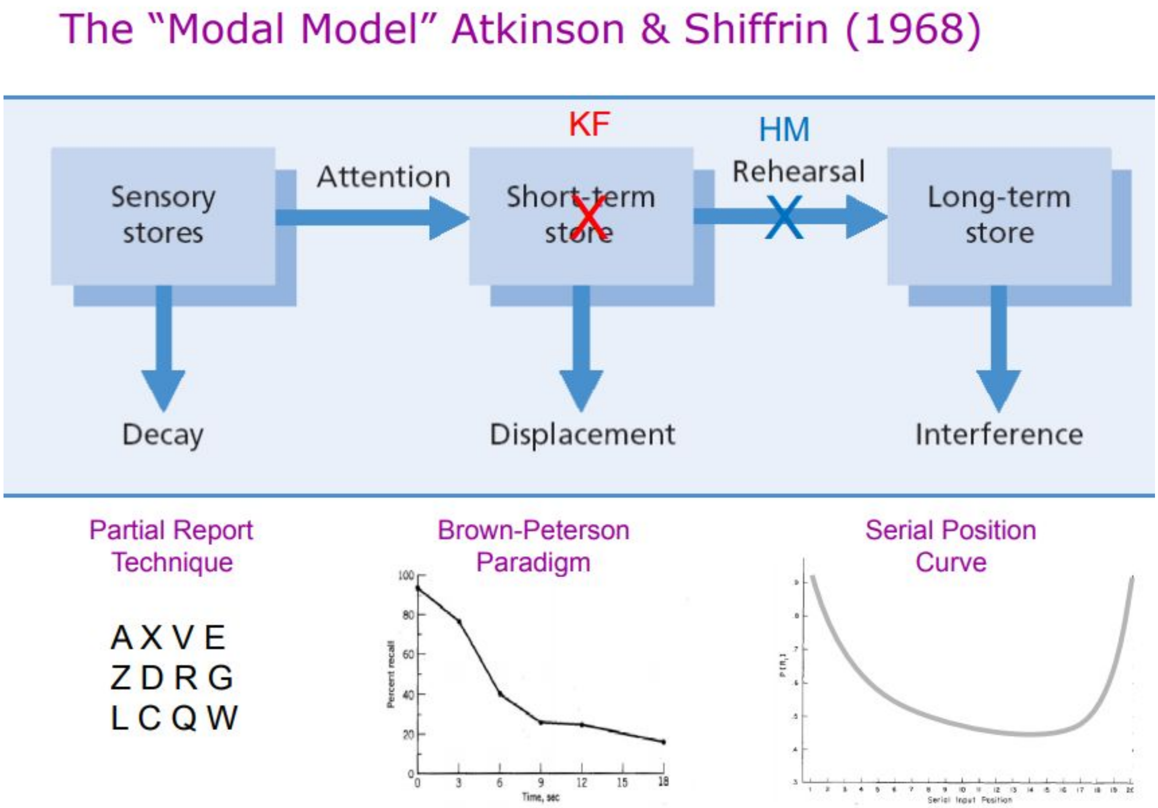
New memories are **initially labile** and sensitive to disruption before becoming progressively more stable (that could be why HM forgot up to 3 years prior to his surgery). Consolidation is also **selective**.

Reconsolidation bases itself on retrieving a memory, as it seems to put it in a labile state again.

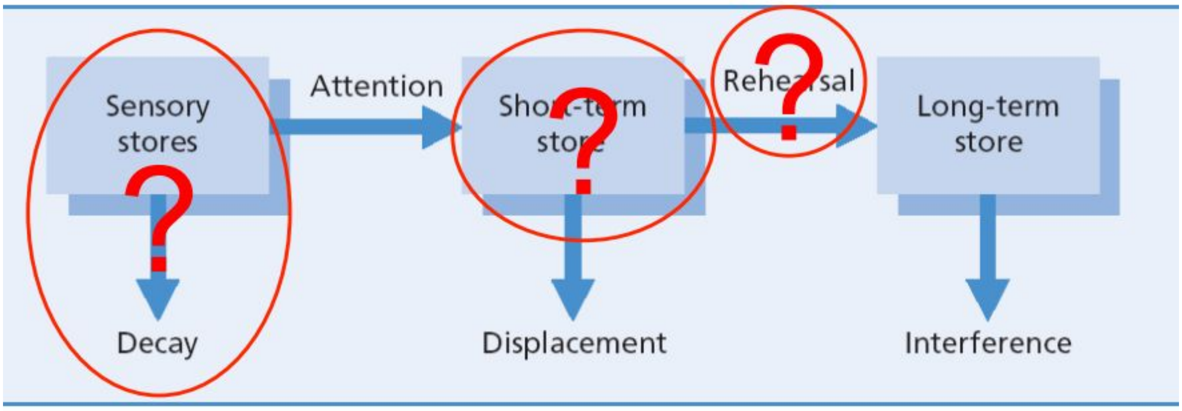
Reading:

Eysenck & Keane (6th or 7th edition), chapters 6 & 7

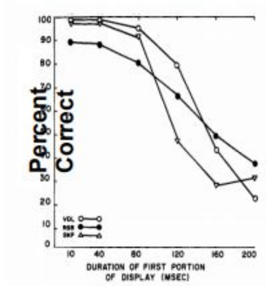
Memory Recap



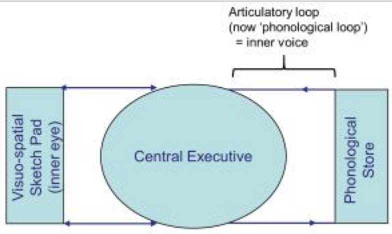
Storage or Process?



Icon or Persistence?



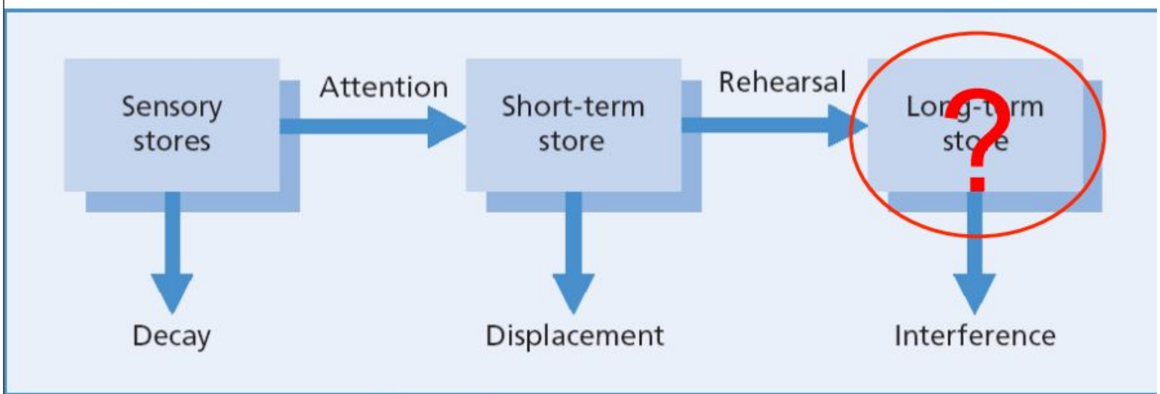
Short-Term Store or Working Memory?



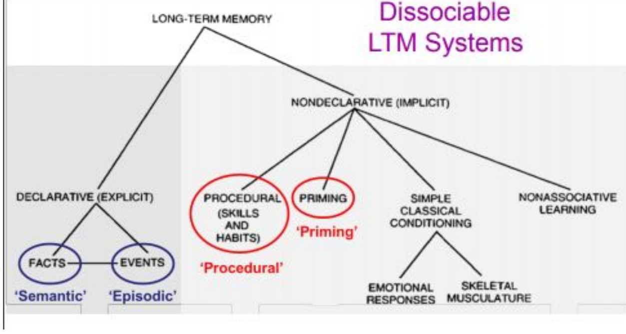
Type of processing	*Level*	*Retention*
Orthographic	Shallow	Poor
Phonological		
Semantic	Deep	Good

Rote Rehearsal
Or
Levels of Processing?

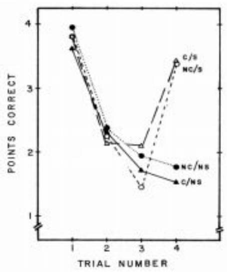
Problems with the "Modal Model"



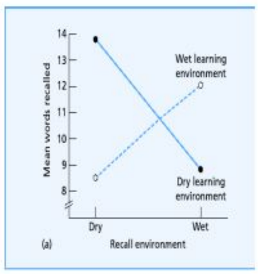
Dissociable LTM Systems



Interference



Cue Dependence



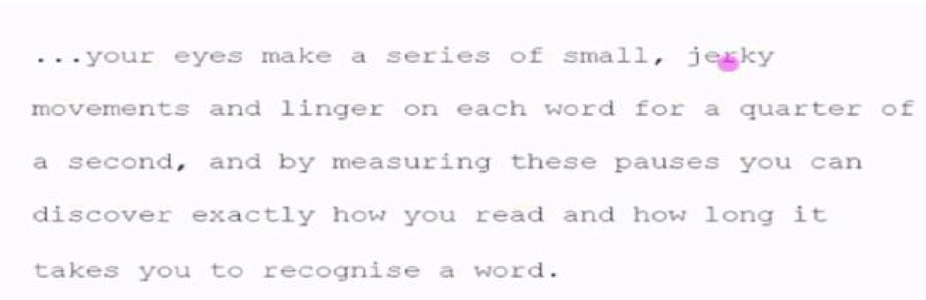
Language I (Lecture 9): Reading - Parsing and Event Indexing Model

Language input is often highly ambiguous. Some words can have different meanings (polysemics like **bank**), and words and phrases with different meanings can have similar sounds (**four candles** vs. **fork handles**). Generally language is understood through **context**. One same phrase can have different meanings depending on the culture or country, for example (Brit sarcasm vs. American forwardness).

Eye Tracking while Reading

When reading, eye-movements consist of eye fixations (for about 250 msec. each) and saccades (where the eye jumps from one location to another). 10-15% of all eye-movements are **backwards**. These are called **regressions**, allowing the reader to relook at previously read text.

When fixating at a point in a word, you can see about 4 characters to the left and about 12-15 characters to the right of fixation. This is called the **perceptual span** (McConkie & Rayner, 1975).



Eye tracking while reading text (a bit slower than real time)

Rayner and Duffy (1986) report **increased** reading times when a **low frequency** word appears in a sentence compared to a high frequency one ("The concerned *steward* calmed the child" vs. "The concerned *student* calmed the child").

Understanding Sentences or Parsing

The act of computing the syntactic structure of sentences is called **parsing**. Sentence parsing involves determining the relationship between the different elements of a sentence and assigning them to syntactic categories (e.g. noun, adjective, verb, etc…). While we might not explicitly have the rules written in our head, we subconsciously know it.

- **Syntax**: building of sentences according to grammatical rules, arrangements of words into an order that results in a meaningful sentence.

- **Grammar**: set of rules concerning which word orders are acceptable and which are unacceptable and on parts of speech

This parsing has developed in humans at a point where we can't read any faster without losing part of the information.

It's also possible for two sentences to have very different syntactic structure, but having the same meaning ("The dog bit the man" vs. "The man was bitten by the dog"). We have little conscious difficulty extracting the meaning of sentences as we have no problem discovering the syntactic relations between different elements.

It's important to note that the majority of studies on parsing have used only the English language, which has stricter parsing rules as, say, German.

Ambiguity

It's possible to have **local ambiguity**:

- *When Fred passes the ball* it always gets to its target
- *When Fred passes the ball* always gets to its target

Here, "the ball" is **temporarily ambiguous**, as it could either be the object of the verb or the subject of the next phrase. The ambiguity could have been resolved with commas before however.

If we consider "The spy saw the cop with the binoculars," this phrase displays **global ambiguity**. Is it the spy who has the binoculars and is using them to see the cop (*Verb Phrase Attachment*), or is it the cop that has the binoculars (*Noun Phrase Attachment*)? This phrase remains ambiguous even in its entirety, as it could take two very different meanings.

Models of Parsing

How does the language processing system decide whether the VP- or NP-attachment interpretation is correct?

Garden Path Model

There's one class of parsing models that says you use syntactic information to construct the "simplest" syntactic representation. The **Garden Path Model** (Frazier, 1979) defines simplicity in terms of the simplest syntactic structure you can make:

1. Identify syntactic categories and build initial structure

2. Assess outcome against context, real-world knowledge and semantic plausibility
3. Revise if necessary

The model makes multiple assumptions, including that only **one syntactical structure** is initially considered for any sentence, and that **meaning** is **not** involved in the selection of the initial syntactical structure.

One of the most famous examples for a garden-path sentence is *"The horse raced past the barn fell,"* which would be much easier to understand if it was written as *"The horse **that** raced past the barn fell."* It's entirely grammatically correct, but the reader is misled at first in its structure, leading to a nonsense sentence when *"fell"* is read.

This model generated lots of experiments, but the bulk of the evidence suggests that syntax **isn't special**, as lots of different types of information influence parsing as it unfolds in real-time.

One of the bigger problems in this model is that we generally don't tend to listen to unique, isolated phrases, we tend to hear **discourses** instead.

Discourse Processing

Three Levels of Representation

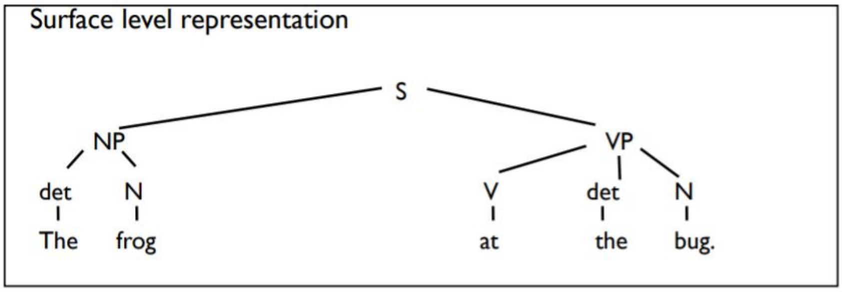
Discourse processing is very important and involves the linking together to construct a coherent mental representation. Van Dijk and Kintsch (1983) proposed that understanding a discourse involves **three levels of representation**:

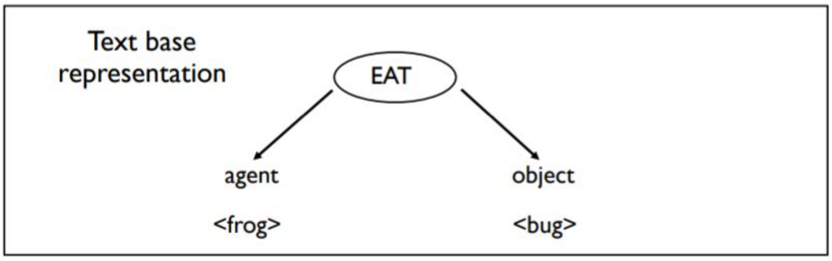
- Surface form (superficial relations between words and sentences)
- Text base (individual meanings of individual words, propositions, statements)
- Situation model (general idea, visual representation…)

(1) The frog ate the bug.
(2) The bug was eaten by the frog.
(3) The frog had the bug for breakfast.
(4) The bug had the frog for breakfast.

- Each sentence has a unique surface code.
- (1) and (2) have the same text base (or propositional) representation.
- (1), (2) and (3) generate the same situation model.

Displaying the three levels of representation





Memory for the **surface form** of a discourse is **rapidly lost**. People remember is something akin to the text base and the situation model levels of representation:

Bransford, Barclay and Franks (1972)

1A Three turtles rested on a floating log, and a fish swam beneath them.

1B Three turtles rested on a floating log, and a fish swam beneath it.

2A Three turtles rested beside a floating log, and a fish swam beneath them.

2B Three turtles rested beside a floating log, and a fish swam beneath it.

- Participants heard 1A or 2A during an initial phase. When they heard sentence 1B in the testing phase (following sentence 1A), they thought they had heard that sentence in the initial phase.

- However, when they heard sentence 2B, they didn't confuse it with 2A. As 1A and 1B lead to the same situation models (and 2A and 2B lead to different situation models) Bransford et al. concluded that readers remember text at a situation model level.

Bransford et al. (1972) argued that readers typically construct a relatively complete **mental model** of the situation and the events described in the text. This mental model is an internal representation of the text. A key implication of this is that numerous elaborative inferences are drawn during reading even when such inferences are not required to understand the text.

Inferences

An **inference** is a piece of information not explicitly stated in the text but represented in a **situation model**. For example, in Bransford et al. the fish swimming beneath the log is an inference that the reader could draw after reading 1A.

Are inferences encoded automatically as people read?

Logical inferences are based on formal rules and, as a result, are 100% certain:

> Julie had seven oranges and gave five to Paul
>
> *therefore* Julie had two oranges left

Example of logical inference

Bridging inferences, also known as **backward inferences**, help us relate new information to previous parts of the text, using them to increase coherence between both parts of a text:

> Mary unpacked some picnic supplies. The beer was warm.

Example of bridging inference

Elaborative inferences involve extending what is in the text with our world knowledge, using semantic associations to add details to a text that is being read.:

> The delicate vase fell on the concrete floor.

Example of elaborative inference

Reader preference also influences inference generation. For example, the phrase "The director and cameraman were ready to shoot close-ups when suddenly the actress fell from the 14th story" was interpreted in different ways in Rapp and Gerrig (2006). If the actress was portrayed in good light, people inferred that she survived. If the actress was portrayed in a bad light, people inferred she was very injured or died. Our feelings about characters in the story influence our inferences.

Event Indexing Model

Zwaan, Langston and Graesser (1995) proposed the **event-indexing model**. It proposes that readers keep track of events that are connected along these five dimensions:

- **Temporality**: relationship between the times at which the present and previous events occured
- **Spatiality**: relationship between the spatial setting of the current event and a previous event
- **Protagonist**: central character or actor in the present event compared to the previous one
- **Causality**: casual relationship of the current event to the previous one
- **Intentionality**: relationship between the character's goals and the present event

Discontinuity in any of the five aspects leads to more processing effort than when all five aspects or indexes remain the same. It's assumed that each dimension is monitored **independently** from each other. When two aspects change at the same time instead of only one, this also takes greater processing effort.

There can be **global updating** when we try to **predict** the near future as we read a text or observe a scene. Such predictions become harder to make as we approach the boundary between one event and the next, which can trigger construction of a new model.

Spatial Information

O'Brien and Albrecht (1992) examined how readers keep track of **spatial information** during reading. Participants read passages as this:

> As Kim stood [inside/outside] the health club she felt a little sluggish. Workouts always made her feel better. Today she was particularly looking forward to the exercise class because it had been a long, hard day at work. Her boss had just been fired and she had to fill in for him on top of her own work. **She decided to go outside and stretch her legs a little.** She was getting anxious to start and was glad when she saw the instructor go in the door of the club. Kim really liked her instructor. Her enthusiasm and energy were contagious.

Passage given in O'Brien and Albrecht (1992)

Reading times for the critical sentence (in bold) were **increased** in the **inconsistent condition** (outside) than in the consistent condition (inside). In another study, they found similar effects for sentences that were consistent or inconsistent with physical properties of the central character (young/old person running quickly). This shows that readers do generate inferences as they read, as if they didn't, these inconsistencies would not have caused such a processing disruption.

Time

Speer & Zacks (2005) examined how event boundaries are mentally represented during reading. They presented wreaders with probe words after time shifts (a moment later/an hour later). The probe words related to content that was presented before the time shift.

Participants were **slower** to respond to probe words after long time shifts. This suggests that the long time shift resulted in information related to events before the time shift being **less accessible** to memory.

Protagonist

There can be multiple expressions to refer to one same person (“Martin”, “you”, “he”, “him”, “I”, etc…), but different expressions are used depending on context and who is speaking (“I” as an expression to refer to myself would only be used by myself or someone doing identity theft).

Shifts in Time, Space and Protagonist

Shifts in time and protagonist always cause an **increase in reading times** according to Therriault, Rinck & Zwaan (2006). However, spatial shifts had their biggest effect only when experimental instructions asked readers to focus on that aspect of the story.

Anaphoric processing

Anaphors, words that refer back to another word or sentence to take their meaning from, can differ in their level of ambiguity. This is a form of **bridging inference**. In the following example of Haviland & Clark (1974), sentence (3) took more time to be read after (1) than (2):

(1) Mary unpacked some picnic supplies.

(2) Mary unpacked some beer.

(3) The beer was warm.

Haviland & Clark (1974) example sentence succession

When readers encountered “the beer” in (3) after reading (1), a search for an explicit antecedent was searched. As it was not found, readers engaged in **inferential processing**, taking time. This was necessary in order to maintain **textual cohesion**.

However, Sanford and Garrod (1983) showed that for **highly constraining contexts**, situational anaphora can be **easy to understand**:

(1) Keith took his car to London.

(2) Keith drove to London.

(3) The car kept overheating.

Sanford and Garrod (1983) example sentences

(3) was as easy to read after (1) than as (2), as the verb “drove” inferred that Keith was in a vehicule of sorts. However, it doesn’t work for **pronouns** suggesting that they usually need explicit antecedents:

Keith drove to London yesterday.

It kept breaking down.

Difficult anaphora in Sanford and Garrod

Pronouns can only carry number and gender information, matching many possible referents in a text. But, pronouns refer to characters that are **in focus**, making their interpretation easy. In fact, they can make a text **easier** to read:

(1a) Bruno was the bully of the neighbourhood.

(1b) Bruno chased Tommy all the way home from school one day.

(1c) Bruno watched Tommy hide behind a big tree and start to cry.

(1d) Bruno yelled at Tommy so loudly that the neighbours came outside.

(2a) Bruno was the bully of the neighbourhood.

(2b) He chased Tommy all the way home from school one day.

(2c) He watched Tommy hide behind a big tree and start to cry.

(2d) He yelled at Tommy so loudly that the neighbours came outside.

Gordon, Grosz and Gilliom (1993) repeated name penalty example

In the example above, there was a reported **repeated name penalty** when reading (1) when compared with (2). This is explained by the **Centering Theory** (Grosz, Joshi, & Weinstein, 1995). The repeated name penalty arises when the character in focus is referred to using a proper name rather than a pronoun, as it’s constantly shifting attention during the discourse when it would technically not be needed.

Quantifiers

Sanford, Moxey and Paterson (1996) showed how different discourse elements can be brought into focus depending on how they're introduced. Participants were given the two following sentences:

1. A few of the fans went to the match. They ______
2. Few of the fans went to the match. They ______

People are likely to continue (1) with something like **"**had a really good time", while (2) was more likely to be continued with something like "watched it on TV instead". "They" was then being used to refer to **different sets of people** in each of the two cases.

Similar effects were found with **scalar expressions** in Jarvella et al. (1995):

In the first round, John Smith got almost/only 500 votes.

The Irish lawyer was leading.

Jarvella et al. (1995) example

The difference between "almost/only 500 votes" influenced how "the Irish lawyer" was interpreted. With "almost", it referred back to "John Smith". With "only", it referred to some other unmentioned person.

Depth of Processing in Language Comprehension

Answer the following question: *How many animals of each type did Moses take on the Ark?*

Erickson and Mattson (1981) found that participants tended to respond "two" rather than realise that it was Noah, not Moses, who was engaged in the Ark episode. This is the **Moses illusion**.

There are higher detection rates of the anomaly if participants were given the sentence "*After a bicycle crash, where should the survivors be buried?"*. Normally people don't die after a bicycle crash, so the idea of anybody being buried was **hard to integrate** with the **situation knowledge**. Therefore, the anomaly with "survivors" was more prone to be discovered.

Reading

Eysenck & Keane (6th or 7th edition), chapter 10

Language II (Lecture 10): Speech Production and Perception

Language is a system of **symbols** (written and spoken words, signs) and **rules (**grammar, etc…) that enable us to communicate. It's **rapidly produced** and **understood**, but it's an extremely complex system.

Components of Language

Before we start, it's necessary to know about the different components in language:

- **Phonemes**: elementary (smallest) units of sound
- **Morphemes**: elementary (smallest) units of meaning in language (e.g.: in-com-ing)
- **Phonology**: rules governing the sounds of words and parts of words (e.g.: "the" with /ðə/ when followed by consonant, and /ðiː/ when followed by vocal or emphatic form)
- **Syntax**: rules governing word order and meaning resulting in sentences
- **Semantics**: meanings of words and sentences
- **Pragmatics**: use of language as a function of content and social rules ("Hello" vs. "hi" vs. "hey" vs. "yo"). It's a study of the ways language is used and understood in the real world, including a consideration of its intended meaning. It includes **figurative language**.

Speech Production

Not Straightforward

At first, speech production seems straightforward as the average speech rate is around 150 wpm, but there can be errors too:

- **Speech errors**: "[...] the national committee of orgasm, I mean, organ donors [...]" ⇐ Actual example used in class don't come attacking me afterwards
- **Underspecification**: "[...] I like travelling, hiking, and you know, things like that [...]"

Furthermore, we have to consider **motivational** and **social** factors in addition to purely linguistic ones. We also have to consider the **planning** that occurs before speaking.

Mental Operations

There are three important mental operations that happen during speech production:

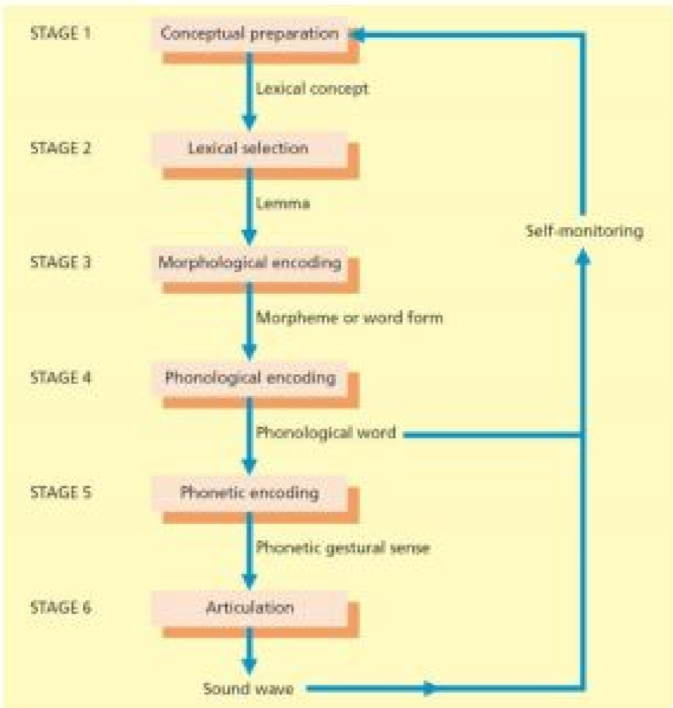
- Conceptualization
  - Think of something to say
- Formulation
  - Find a way to express your idea given the specific language tools
- Articulation
  - Physical action of moving your muscles to produce speech

Mental operations

These happen in **parallel**.

WEAVER++

This theory was presented in Levelt et al. (1999), and showcases the process of speech production in a **serial** and **looping** way:



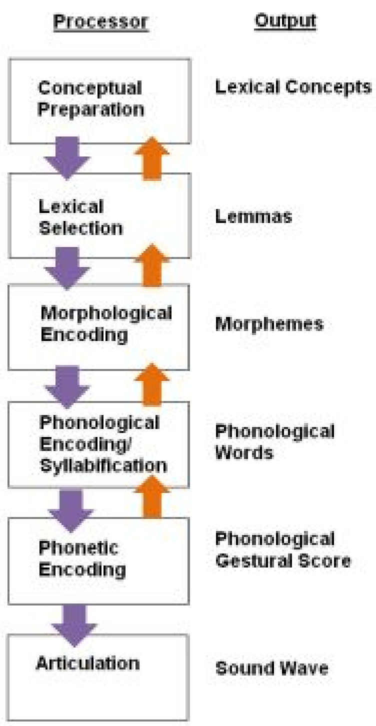
1. Idea
2. Zoom in on the appropriate lexical item in the mental lexicon (→ lemma level)
3. Retrieve a word's morphemic code
4. Retrieve a word's phonological code
5. Syllabify the word & access the corresponding articulatory gesture
6. Move the muscles and produce speech waves

WEAVER++ Visualization

It's a **feed-forward information flow**. It acknowledges the existence of an intermediate stage called **lemma**, which happens between activating an idea and the speech sound. It also details that the link from meaning to sound (**lexicalisation**) is a **multiple stage process**. Those levels are:

- **Semantic**: the planning level, the meaning of what is to be said or the message to be communicated
- **Syntactic**: grammatical structure of the words in the planned utterance
- **Morphological**: morphemes, basic units of meaning
- **Phonological**: phonemes, basic units of sound

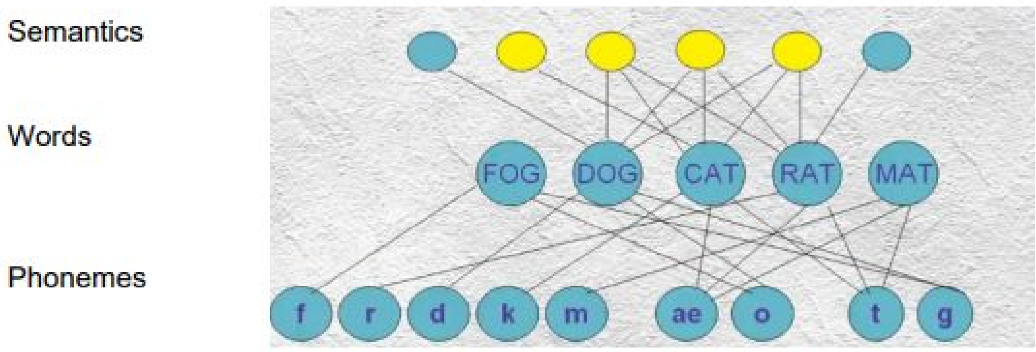
Spreading Activation



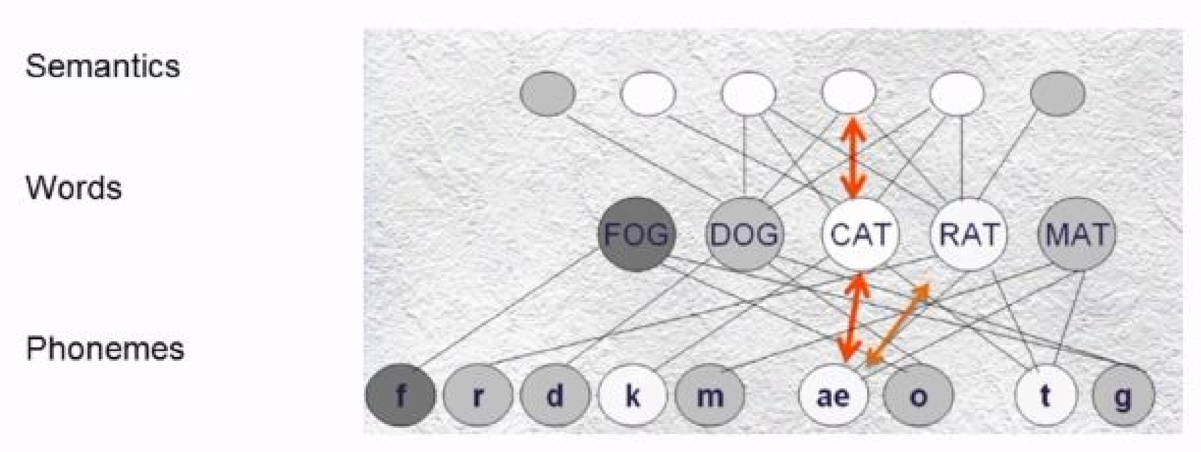
Spreading Activation Model

This model, proposed by Dell (1986), works **Top Down, Bottom Up**. The flow is **interactive**, and goes from meaning to sound, and back from sound to meaning. The **lemma** is once again acknowledged, and this theory presents the **lexicalisation** as a **multiple stage process** that works in **parallel**. This model explains slightly better the speech errors we encounter than WEAVER++ does.

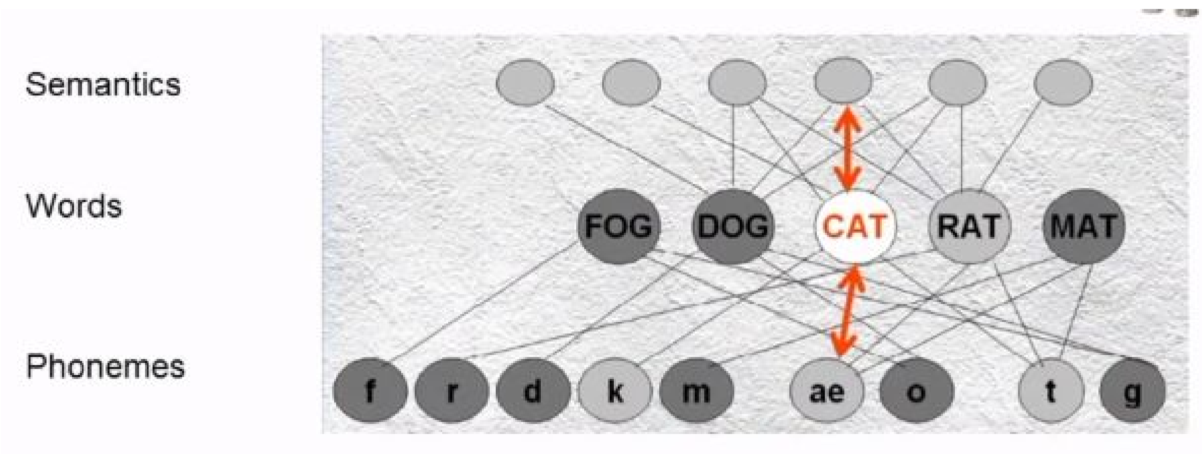
This is more difficult to visualize than WEAVER++. Imagine we want to say to someone "this animal is a **cat**":



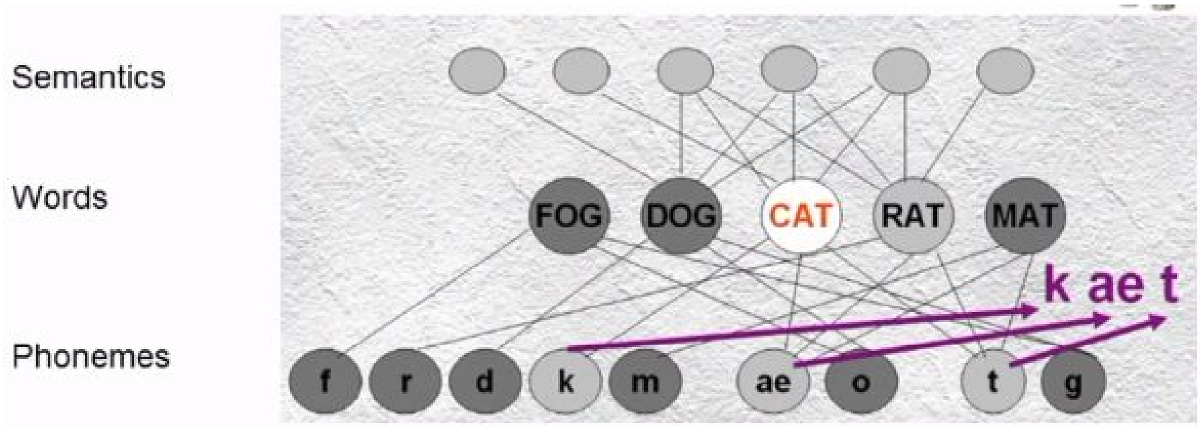
The semantic areas related to the visual stimulus are activated (in yellow)



Sounds related to "CAT" are activated (phonetically or semantically), displayed in white



Loop feeds back from the bottom, winning candidate is "CAT"



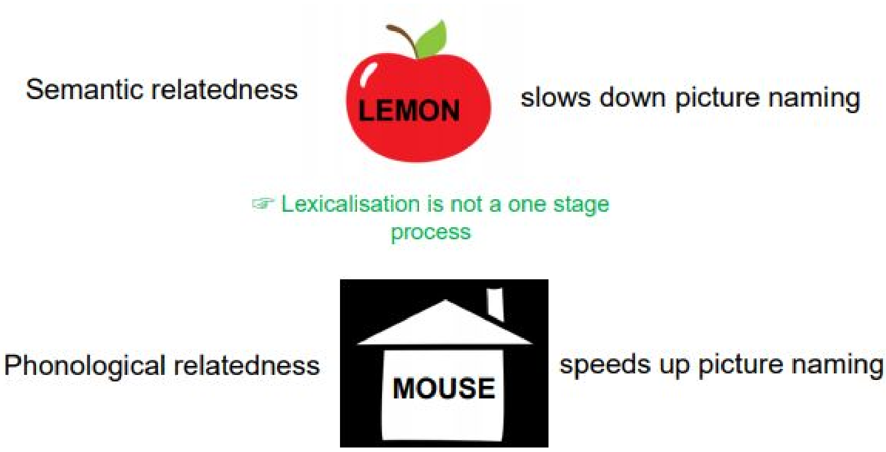
Sound for "CAT" is produced

Supporting Evidence

The **tip-of-the-tongue state** (TOTs) (https://www.youtube.com/watch?v=sFeibGnZ6tc) occur when we have an idea or concept in mind but cannot find the appropriate word.
While in TOTs, people can retrieve the first phoneme of the target word, the number of syllables of the target word, and the gender of the target word. This supports that **lexicalisation** is a **multi-stage process**: we're stuck in one stage and can't progress to the next one. Usually, most of the TOTs occur with **low-frequency words** (Harley & Bown, 1998).

This supports the **spreading activation model**. It's as if the **semantic** nodes are activated, but **sound clusters don't completely**. Maybe it's because the signal has made a **detour**, not following the correct path. Hence, we can remember maybe the first syllable, the meaning, but we can't produce the full sound. **WEAVER++** is less supported by this, as we can retrieve parts **further down** than where we would be, impossible with WEAVER++ as there's no constant feedback.

Picture-word interference can either slow down or speed up picture naming:



Two cases of picture-word interference

As there are different kinds of interference, it shows that **semantics** and **phonology** are two different stages in **lexicalisation**, making lexicalisation a **multi-stage process**.

Speech errors are the most useful to understand how speech production works:

	Utterance	Target
Semantic substitution	Where is my tennis bat	Where is my tennis racquet
Word-exchange	My chair looks empty without my room	My room looks empty without my chair
Sound-exchange (*spoonerisms*)	Go and shake a tower	Go and take a shower

Types of speech errors

Errors are **not random**:

- **Lexical bias effect**: “Fig beet” instead of “big feet” happens more often than “hig borse” instead of “big horse” (Baars, Motley, & MacKay, 1975). You can only produce **actual words** as errors but not invented.

- **Mixed-error effect**: “Let’s start” but not “let’s begin” instead of “let’s stop”. We tend to produce errors with a similar **phonology** to the target word.

- **Sound-exchange** type of errors are similar to **spoonerisms**, in which the initial letter or letters of two words are switched to form two different words.

All models support **lexicalisation** as a **multi-stage process**, but they support the **spreading activation model** (interactive) better than **WEAVER++** (feed-forward):

	WEAVER++	Spreading Activation Model
TOTs	✓ (?)	✓
Picture-word interference	✓	✓
Speech errors	✓ (?)	✓

BUT
Lexical bias effect
Mixed-errors

BUT
Prospecting

Spreading Activation Model is more satisfactory than WEAVER++

Pronunciation

Try reading the following words aloud:

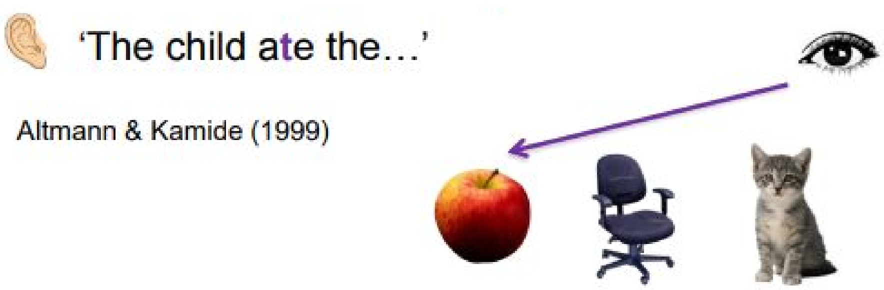
CAT FOG COMB PINT MANTINESS FASS

How do you know the "b" in COMB is silent, and that PINT does not rhyme with HINT? It surely is because you have specific information in **memory** about how to pronounce these words.

However, for **non-words**, this information does not exist, so we don't know how to pronounce them. We could associate them to already existing words (FASS/BASS or FASS/FAST), but this shows how a specific pronunciation for each word is one of the **features** of said word.

This suggest also that the spreading activation model is more satisfactory than WEAVER++

Speech Perception



The eye gaze shifts towards the apple very fast, when the sound "t" is heard in "ate"

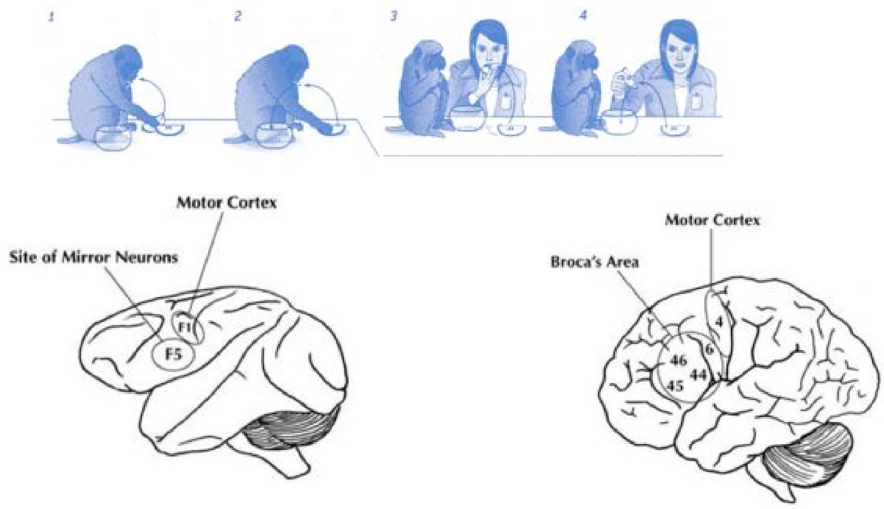
Perception of speech seems to be **global** and in **multiple stages**.

Speech perception works almost as speech production, but upside down. **Co-articulation** is important too, as the pronunciation of a phoneme by a speaker depends on the preceding and following phonemes (e.g.: "the"). While there's no one-to-one relationship between acoustic signal and phonemes, it allows for **prediction** and makes **perception faster**.

There is increasing evidence that **orthography** is involved in speech perception. Perhaps hearing a word leads fairly automatically to activation of its orthographic codes, influencing lexical access. Maybe it's the other way around. We don't know, as studies on this topic are fairly recent (Perre And Ziegler, 2008).

Motor Theory

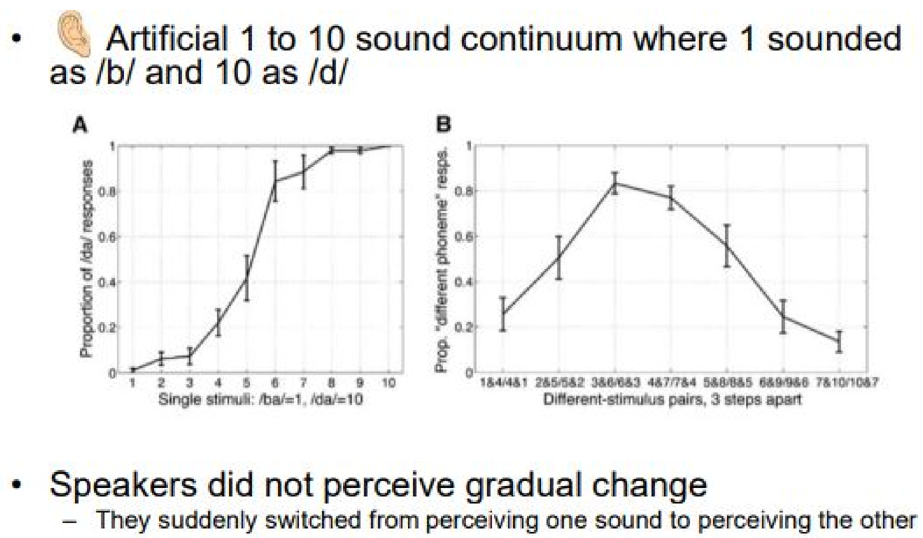
In the **motor theory** (Liberman et al., 1967), 'listeners perceive spoken words by reproducing the movements of the speaker's vocal tract rather than by identifying the sound patterns that speech generates’. The motor system is involved in **both** speech **production** and **perception** (mirror neurons, Rizollatti’s work in the early ‘90s).



Same neurons are activated when watching an action than when performing it

There’s quite a bit evidence for this theory. The **McGurk effect** (https://www.youtube.com/watch?v=G-lN8vWm3m0) is an illusion which occurs when the auditory component of one sound is paired with the visual component of another sound, leading to the perception of a third sound. We integrate **non-acoustic information** into what we hear, our **auditory** and **visual** information processing is merged.

Categorical speech perception also supports this motor theory. We can’t hear half of a phoneme and half of another:



Categorical Speech Perception in Raizada & Poldrack (2007)

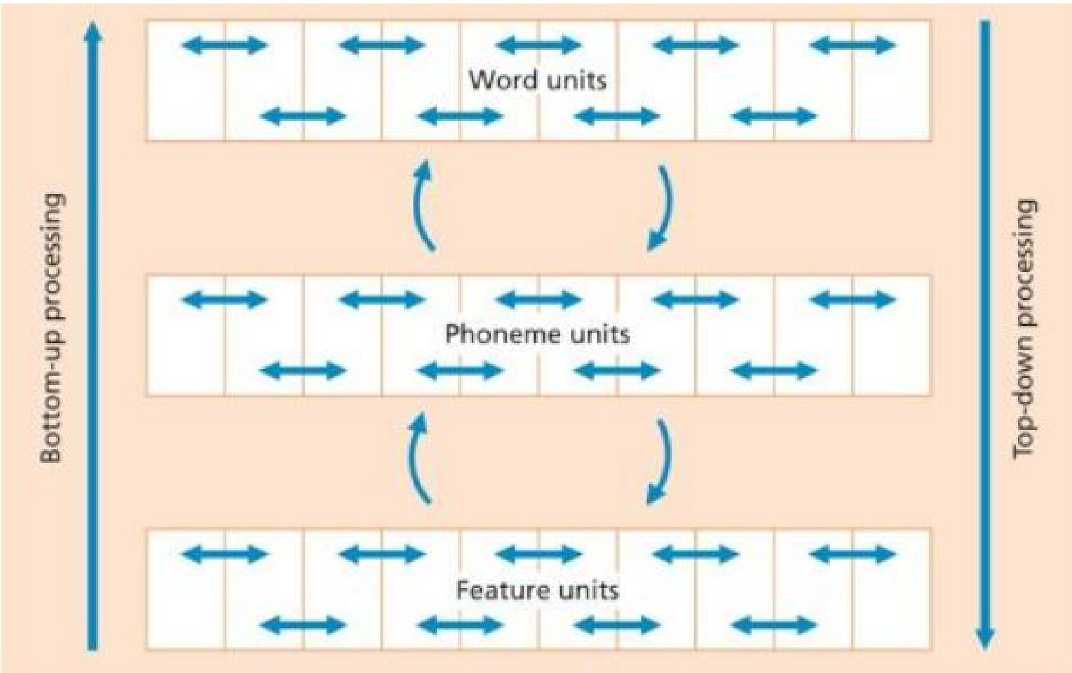
There is better discrimination of pairs of sounds when sounds are more different from each other (passing the **crucial point**, changing the % of phoneme).

The **motor cortex** has been studied in the context of speech perception. **fMRI** shows that when listening to speech and imagining to be speaking **activates** the speech motor cortex. Motor **TMS** (Transcranial Magnetic Stimulation) **decreases** phoneme discrimination, as the motor cortex is being used for something else.

While robust, this theory has some limitations. **Infants** don't produce speech but can still understand it, **stroke patients** can produce (nonsensical most of the time) speech but can't understand it. It also doesn't mention anything about **context effects**. While motor areas are also involved in speech perception, it seems that non-motor areas are much more important.

TRACE

The **TRACE** model (McCLelland & Elman, 1986), also called the **interactive activation model**, is similar to the **Spreading Activation** speech production theory, as t has **bottom-up** and **top-down** interactions too, but the other way round:



Basic TRACE model

The model assumes that there are individual processing units or nodes at three different levels: **features** (voicing, manner of production), **phonemes** and **words**. The connection **between levels** operate in both directions and are always **facilitatory**. Connections at the **same level** are **inhibitory**. The word recognised or identified by the listener is determined by the activation level of the possible candidate words.

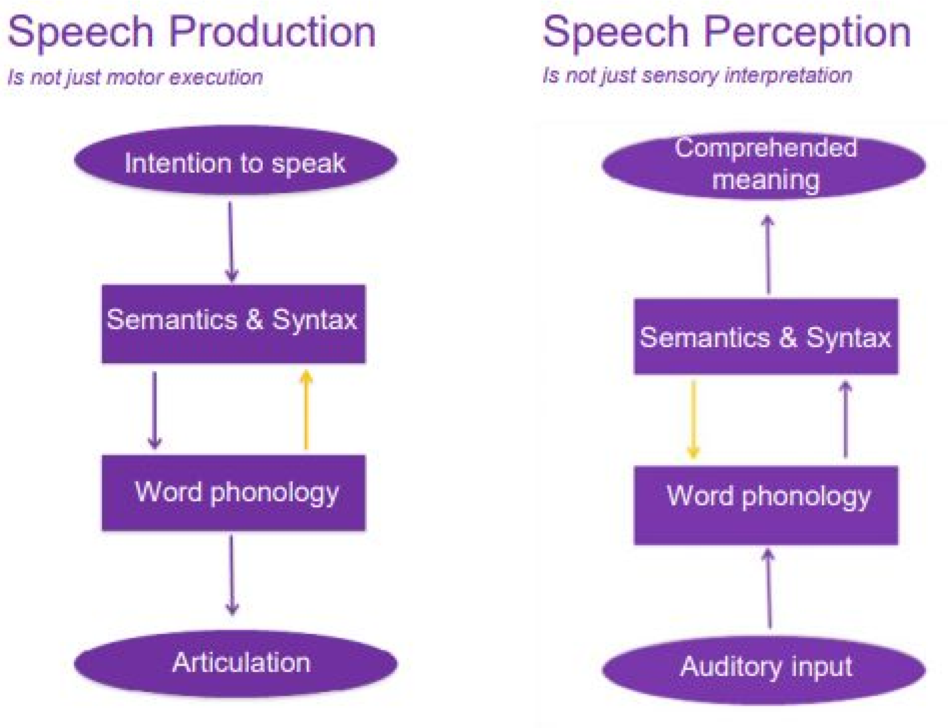
There is evidence for this, including the **lexical identification shift**, also known as the **Ganong effect**: when you hear sounds ranging from /dash/ to /tash/, phonemes were assigned to words rather than non-words. The **word superiority effect** is also linked to this, which makes a target letter more readily detected in a letter string when the string forms a word than when it does not. These two effects suggest the presence of **top-down** processing.

The **phonemic restoration effect** (http://www4.uwm.edu/APL/demonstrations.html, single/multiple phonemic restoration by noise) reports full hearing of a word even if it was cut, and correct on context: “It was found the ?eel was on the shoe” ⇒ “heel” is heard. “It was found that the ?eel was on the orange” ⇒ “peel” is heard (Warren & Warren, 1970).

Furthermore, **high-frequency** words are generally recognised **faster** than **low-frequency** ones. It would be consistent with the model, as they would have higher resting activation levels.

Of course, it also has some **problems**. It attaches excessive importance to top-down processes in spoken word recognition. Only some **contextual** factors are considered, and **inferences** usually aren’t.

Summary



Reading

Eysenck & Keane (7th edition), chapter 9 p. 386-393 & chapter 11 p. 451-470