**Progress Check: Cognitive Psychology**

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| **DO YOU KNOW…** | ? | ? | ? |
| **CONTENT** |  |  |  |
| The working memory model (Baddeley and Hitch, 1974) |  |  |  |
| The multi-store model of memory (Atkinson and Shiffrin, 1968), including short- and long-term memory, and ideas about information processing, encoding, storage and retrieval, capacity and duration |  |  |  |
| Explanation of long-term memory – episodic and semantic memory (Tulving, 1972) |  |  |  |
| Reconstructive memory (Bartlett, 1932) including schema theory |  |  |  |
| Individual differences in memory processing speed or by schemas that guide the reconstructive nature of memory.  |  |  |  |
| Developmental psychology in memory: Sebastián and Hernández-Gil (2012) discuss developmental issues in memory span development, which is low at 5-years old, then develops as memory develops, up to 17-years old.  |  |  |  |
| Dyslexia affects children's memory, span and working memory which can affect their learning.  |  |  |  |
| **METHODS** |  |  |  |
| Designing and conducting experiments, including field and laboratory experiments. |  |  |  |
| Independent and dependent variables. |  |  |  |
| Experimental and null hypotheses |  |  |  |
| Directional (one-tailed) and non-directional (two-tailed) tests and hypotheses. |  |  |  |
| Experimental and research designs: repeated measures, independent groups and matched pairs. |  |  |  |
| Operationalisation of variables, extraneous variables and confounding variables |  |  |  |
| Counterbalancing, randomisation and order effects |  |  |  |
| Situational and participant variables. |  |  |  |
| Objectivity, reliability and validity (internal, predictive and ecological) |  |  |  |
| Experimenter effects, demand characteristics and control issues |  |  |  |
| Analysis of quantitative data: calculate measures of central tendency, frequency tables, measures of dispersion (range and standard deviation), percentages.  |  |  |  |
| Graphical presentation of data (bar graph, histogram) |  |  |  |
| Decision making and interpretation of inferential statistics |  |  |  |
| Non-parametric test of difference: Mann-Whitney U and Wilcoxon |  |  |  |
| Probability and levels of significance (p≤.10 p≤.05 p≤.01). |  |  |  |
| Observed and critical values, use of critical value tables and sense checking of data. |  |  |  |
| One- or two-tailed regarding inferential testing. |  |  |  |
| Type I and type II errors. |  |  |  |
| Normal and skewed distribution |  |  |  |
| Case study of brain-damaged patients, including Henry Molaison (HM) and the use of qualitative data, including strengths and weaknesses of the case study. |  |  |  |
| **STUDIES**  |  |  |  |
| Classic study: Baddeley (1966b) Working memory model: The influence of acoustic and semantic similarity on long-term memory for word sequences |  |  |  |
| Contemporary Study: Sebastián and Hernández-Gil (2012) Developmental pattern of digit span in Spanish population. |  |  |  |
| **KEY QUESTION** |  |  |  |
| Key Question: How can knowledge of working memory be used to inform the treatment of dyslexia? |  |  |  |
| **PRACTICAL INVESTIGATION**  |  |  |  |
| Dual task experiment to investigate components of working memory. |  |  |  |

**WORKING MEMORY MODEL: BADDELEY AND HITCH (1974)**

Baddeley & Hitch questioned the existence of a single STM store, arguing that STM was more complex than being just a temporary store for transferring information to LTM. They instead saw STM as an ‘active’ store, holding several pieces of information while they are being worked on (hence ‘working memory’). Replacing the single STM, Baddeley & Hitch proposed a multi-component WM comprising three components based on the form of processing each carried out. (A fourth component was added later by Baddeley & Lewis (1982)).

**The central executive** (CE): is the filter that determines which information is and is not attended to. It processes information in all sensory forms, directs information to other ‘slave’ systems and collects responses. It is limited in capacity and can only cope effectively with ‘one’ strand of information, attaining a balance between them, for example, talking while driving. It also permits us to switch attention between different inputs of information. The central executive is viewed as a homunculus (a very small human) with a supervisory role in deciding how the two slave systems should function. The central executive can deal with different types of sensory information therefore making it modality free (able to process different forms of information e.g. acoustic, visual, haptic etc.).

 **Research Study**

BADDELEY (1996) discovered that participants found it difficult to generate lists of random numbers while simultaneously switching between numbers and letters, suggesting that the two tasks were competing for CE resources. This supports the idea of the CE being limited in capacity and only being able to cope with one type of information at a time.

**The Phonological Loop:** This is one of the ‘slave’ systems of the WMM. It is a temporary store that deals with sound. The phonological loop is like the rehearsal system of the MSM with a limited capacity determined by the amount of information spoken out aloud in about 2 seconds. It deals with auditory information.

 **Research Study**

BADDELEY et al (1975) reported on the word length effect, where participants recalled more short words in serial order than longer words, suggesting that the capacity of the phonological loop is set by long it takes to say words, rather than the actual number of words.

Baddeley (1986) divided the phonological loop into two sub-parts: the **phonological store** and the **articulatory process**. The phonological store also known as the **inner ear** and stores words heard, while the articulatory process also known as the **inner voice**, allows sub-vocal repetition of information stored in the phonological loop.

The phonological store can explain the phonological similarity effect, where it is more difficult to remember similar sounding words and letters (man, cad, mat, cap, can) compared to words and letters that sound different from one another (pen, sup, cow, day, hot) however this was not true for words that had sematic similarity or words that were semantically unrelated- this demonstrates that the phonological loop relies on acoustic encoding for storage.

The articulatory rehearsal system was used to explain the word length effect, where short monosyllabic words (cat, rug, and hat) were recalled more successfully than longer polysyllabic words (intelligence, alligator, hippopotamus). Essentially the longer words filled up the limited capacity of the articulatory rehearsal system resulting in the decay of words positioned earlier in the list. The longer the word the more capacity was used up resulting in forgetting being more likely to occur.

**The visuospatial sketchpad:** is the second ‘slave’ system it is known as the **inner eye** and handles non-phonological information and is a temporary store for **visual** and **spatial** items and the relationships between them; essentially, it is a store for what items are and where they are located. The visuospatial sketchpad therefore helps with individuals being able to navigate and interact with their physical environment, with information being rehearsed and encoded using ‘mental pictures’.

 **Research Study**

GATHERCOLE & BADDELEY (1993) found that participants had difficulty simultaneously following a moving point of light and describing the angels on a hollow letter ‘F’, because both tasks involved using the visuospatial sketchpad. Other participants had little difficulty in following the light and performing a simultaneous verbal task, as they involve using the visuospatial sketchpad & the phonological loop, indicating the visuospatial sketchpad to be a separate slave system.

**EVALUATION OF THE WORKING MEMORY MODEL**

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| STRENGTHS | WEAKNESSES |
| * Extremely influential and more plausible model than the MSM because it explains STM in terms of both a temporary storage and active process.
* MSM is structural WMM attempts to explain how the memory functions- lots of research of each section of the model.
* Accounts for individual differences in memory processing.
* It has been applied to various real-life settings.
* PET scans support the WMM as it shows different parts of the brain are used when doing verbal and visual tasks
 | * It does not offer a complete understanding of how memory works.
* The role of the central executive remains unclear.
* The WMM does not explain changes in processing ability occurring because of practice or time.
* WMM only concerns itself with STM and so is not a comprehensive model of memory.
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**MULTI-STORE MODEL OF MEMORY: ATKINSON &SHIFFRIN (1968)**

The multi-store model (MSM), developed by **Atkinson & Shiffrin (1968)** explain how information flows from one storage system to another, with three permanent structures in memory: **sensory memory** (SM), **short-term memory** (STM) and **long-term memory** (LTM). Each memory stage differs in terms of: **Capacity** (how much information can be stored), **Duration** (how long information can be stored) and **Encoding** (the form in which information is stored)

Information received through the senses enters sensory memory. A small fraction is attended to and selected for further processing in Short Term Memory (STM). If not attended to, sensory information is immediately forgotten or not even processed in the first place. If the information is actively processed, mainly through rehearsal, then it may be transferred to Long Term Memory (LTM) for more permanent storage.

**SENSORY MEMORY:** Stimuli coming into the memory system from the external environment first register into sensory store. This holds information for fractions of a second after the physical stimulus is no longer available. The visual sensory register has been widely researched using whole or partial report technique (SPERLING 1960, 1963) in which a visual array of letters is presented via a tachistoscope for a brief moment then an instruction is given to participants to recall the whole or a specific row of the array. Participants typically recalled on average 4.32 letters of the whole array. It was found that the sensory memory can hold information only for a few hundred milliseconds before it is lost.

**SHORT TERM MEMORY:** is an active memory system containing information currently being thought about. STM is a temporary storage of information received from the SM. STM differs from LTM in terms of encoding, capacity duration and duration.

**Encoding in short-term memory:** Information arrives in the SM in its original form, such as sound or vision. This is encoded in a form the STM can deal with. Atkinson and Shiffrin believed that a memory trace in the short term was held in auditory or verbal form because of the phonological similarity effect; letters and words of a similar sound presented to participants are more difficult to recall than dissimilar sounding letters and words. The similarity of the sounds leads to a confusion in the short-term store suggesting that the encoding in this store is primarily acoustic (auditory or verbal).

**Capacity of STM:** STM has a limited capacity; we can hold only a small amount of information before it is forgotten. This can be investigated with the digit span technique, where participants are presented with increasingly long sequences of digits, to be recalled in the correct order (e.g. 26478, 968423, 2975841 and so on). When participants fail on 50 % of the trails, it is said that they have researched their digit capacity. Research indicated a STM capacity of five to nine items. Capacity is increased through chinking where the size of the units of information in memory is increased.

 **Research Study** MILLER (1956)

Miller’s magic number (7 +/- 2): Miller concluded from reviewing research the capacity of STM was between 5 and 9 items, but that the ‘chunk’ (grouping information into meaningful bits) was the basic unit of STM. This meant that between five and nine chunks could be contained within STM, effectively increasing its capacity.

**Duration of STM:** The duration of the STM is fairly limited- less than 30 seconds. Research also indicated that the information is lost rapidly from the STM if it is not rehearsed. Repetition retains material within the STM loop, until eventually it becomes a permanent feature within LTM.

 **Research Study** PETERSON & PETERSON (1959)

AIM: To test how long STM lasts when rehearsal is prevented.

PROCEDURE: Participants were briefly shown a consonant trigram (i.e. three letters such as CPW or NGV). Participants were then asked to count backwards in three from a specified number to stop them from rehearsing the letters. After intervals 3,6,9,12,15 or 18 seconds, participants were asked to recall the original trigram. The procedure was repeated several different times using different trigrams.

FINDINGS: Participants were able to recall about 80% of the trigrams after a 3 second interval. Progressively fewer trigrams were recalled as the time interval lengthened. After 18 seconds, fewer than 10 % of the trigrams were recalled correctly.

CONCLUSIONS: The STM has a very short duration only about 20 seconds if we are unable to repeat what we are trying to remember. Maintenance rehearsal is necessary to prevent information vanishing from STM. Information in STM is lost through decay (i.e. it fades away) if maintenance rehearsal is prevented.

EVALUATION:

* Trigrams are rather artificial things to remember and may not reflect everyday memory.
* It is possible that interference from earlier trigrams (not merely decay) caused the poor recall.

**Retrieval from the short-term store**

Retrieval of memory in the short-term store is largely based on rapid sequential scan of the stored information. Rehearsal is important in maintain the information in the short-term store, increasing the strength of the memory trace and ultimately building up the memory trace in the long-term store. Digit span experiments suggests that we can maintain between five and nine items using rehearsal, and as more information is input into the store, older information or information with a weaker memory trace is knocked out (displaced) and quickly decays.

**Transfer of information between short-term and long-term store**

To transfer information received by our sensory register to the short-term store, we must use our long-term store to make sense of the information and assign it a verbal label. For example, we may register the image of a horse, nut this cannot be stored as an auditory-verbal short-term memory until we have identified it as such using our long-term memory of what the object represents. Transfer of information from the short- term to the long-term store can be a result of rehearsal, although this would leave a relatively weak memory trace. Per Atkinson & Shiffrin, a more durable memory trace can be achieved by using mental operation, such as a mnemonic, to increase the strength of transfer.

**LONG TERM MEMORY**

Long term memory involves the storage of information over extended periods of time, potentially a whole lifetime. Forgetting from LTM may not occur due to loss of information, but rather to problems in retrieving memory traces. Storage of information longer than 30 seconds counts as LTM.

**Retrieval from the long-term store**

Atkinson & Shiffrin believed that memories existed for all sensory modalities; we have memories for taste, sound, smells etc. they proposed that multiple copies of the memory were retained in the long-term store. This is based on evidence from Brown & McNeill (1966) in the ‘tip of the tongue’ phenomenon, which demonstrated that people could accurately predict that they could recognise a correct answer even if they could not recall the correct answer in that moment in time. The individual may feel that the correct answer is on the ‘tip of their tongue’ and many even can recall some features of the correct answer, such as the initial letter or its number of syllables. Atkinson & Shiffrin suggested that these results indicate that the LTM is not stored as one memory trace, but that multiple copies, in their various forms and fragments, are stored. When we experience ‘tip of the tongue’, we are retrieving a partial copy of the memory trace, and this partial copy retrieval can help us gain access to a more complete copy of the long-term memory through some associative process.

**Encoding in long-term memory:** With verbal material, it appears that coding in LTM is mainly semantic (based on meaning), although there is research to indicate a visual and an acoustic code.

**Capacity of long term memory:** The potential capacity of LTM is unlimited. No one has ever shown that their brain is full! Information may be lost due to decay and interference, but such losses do not occur due to limitation of capacity.

**Duration of long term memory:** Memories can last a lifetime, so the duration of LTM depends on an individual’s lifespan. Older people often have very clear childhood memories. Items in LTM have a longer duration if originally well-learned. Certain forms of information have longer duration, like information based on skills rather than just facts. Material in STM that is not rehearsed is quickly forgotten, but information in LTM does not have to be continually rehearsed to be retained.

 **Research Study** BAHRICK et al (1975)

AIM: To establish the existence of very long term memory and to see whether there was any difference between recognition and recall.

PROCEDURE: Investigators tracked down graduates from a particular high school in America over a 50 year period. 392 graduates were shown photographs from their high school yearbook. There were 2 groups in the study:

1. Recognition group- for each photo participants were given a group of names and asked to select the name that matched the person in the photo.
2. Recall group- participants were simply asked to name the people in the photos without being given a list of possible names.

FINDINGS: In the recognition group- participants were: 90% correct even 14 years after graduation, 80% correct after 25 years, 75% correct after 34 years, 60% correct after 47 years

In the recall group participants were: 60% accurate after 7 years AND less than 20% accurate after 47 years

CONCLUSION: People can remember certain types of information for almost a lifetime. Very long term memory appears to be better when measured by recognition tests than by recall tests.

EVALUATION: This study used meaningful stimulus material and tested people for memories from their own lives hence high ecological validity. It is unclear whether the drop-off in accuracy after 47 years reflects the limits of duration or a more general decline in memory with age.

**Research Study** CLIVE WEARING 

Clive Wearing suffers from a particularly profound amnesia which he suffered after contracting a viral infection called encephalitis. He was left with extensive brain damage, which caused major memory disruption.

Psychologists have learnt a lot from the study of people with loss of memory (amnesia) after brain damage. Clive Wearing’s case demonstrates that memory is crucial to our well-being and everyday functioning. The fact that Clive Wearing continues to talk, walk, play music, read and write, in spite of huge memory impairments in his memory for personal history and general knowledge suggests that memory is not a unitary system.

 Even more disturbing is his inability to lay down new memories. Clive is convinced that he has just woken up and keeps a diary in which he records this obsessive thought. Whenever his wife visits, he greets her as if he has not seen her for ages when in fact she may have just left the room for a couple of minutes. Years after the onset of the illness which caused Clive Wearing’s memory loss, he is still trapped in an eternal present- he cannot use the past to anticipate the future. He is unable to enjoy books or TV because he cannot follow the thread. He cannot go out alone because he immediately becomes lost and is unable to tell anyone who finds him where he is going or where he has come from.

**Research Study** GLANZER & CUNITZ (1966)

**Aim**: To see if they could find evidence for the existence of separate short-term and long term memory stores.

**Procedure**: Participants were presented with a list of words, one at a time, and then asked to recall the words in any order (free recall). Participants were put into 2 groups: (Group 1) Immediate recall group- participants were asked to recall the words after they had been presented. (Group 2)Delayed recall group- participants counted backwards for 30 sec before they recalled the words.

**Findings**: the immediate recall group remembered the first (primacy effect) and last (recency effect) words best. The delayed recall group remembered words from the beginning of the list best. Both groups had difficulty recalling the words in the middle of the list. This is the serial position effect.

**Conclusion**: These findings support the concept of separate memory stores as the words remembered from the beginning of the list has been stored in the LTM and the words at the end of the list were still in the STM.

Evaluation of the Multi-Store Model

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| STRENGTHS OF MSM | WEAKNESSES OF MSM |
| * The MSM has made an important contribution to memory research.
* The information processing approach has enabled psychologists to construct testable models of memory and provided the foundation for later important work.
* Most modern researchers would agree that there is a basic distinction to be made between short term, temporary, limited capacity store and the more robust and permanent long term memory- there is plenty of evidence to support this distinction.
* Clinical evidence from case studies supports the distinction between STM and LTM.
* Much of the research comes from laboratory experiments which have high control and are reliable.
 | * Major problem is that it is over-simplified. MSM is too simple and fails to reflect the complexity of the human memory.
* It takes no account of the different types of things we have to remember. It places great emphasise on the amount of information we can handle at one time but not the nature of the information. Some things are easier to remember as they are more relevant, interesting, funnier, etc.
* The role of rehearsal in transferring information from STM to LTM is central to the MSM however there is considerable evidence that simple repetition is one of the least effective ways of passing on information.
* A special type of remember known a ‘flashbulb memory’ (highly emotional, significant and shocking events are imprinted directly on to LTM without any rehearsal) are not accounted for in the MSM.
* Research from laboratory experiments is artificial and lacks eco-logical validity.
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**EXPLANATION OF LONG-TERM MEMORY- EPISODIC AND SEMANTIC MEMORY (TULVING, 1972)**

Endel Tulving first made the distinction between episodic and semantic memory in a book where he aimed to reduce the ambiguity around the nature of long-term memory. He proposed that long-term memory could be divided into two memory stores: episodic memory (remembered experiences) and semantic memory (remembered facts). Tulving proposed that the dissociation between semantic and episodic memory was based on evidence that each store was qualitatively different in terms of the nature of stored memories, time referencing, the nature of associations between memories held in each store, the nature of retrieving or recalling memories held in each store and the independence of each store.

**The nature of episodic and semantic memory:** Tulving suggested that semantic memory represented a mental encyclopedia, storing words, facts, rules, meanings and concepts as an organised body of knowledge. These memories are associated with other facts that link the concepts together (e.g. ‘school and learning’, or ‘bird and nest’) without autobiographical association. For example, the statements ‘I know that June follows May in the calendar’ or ‘South Africa is a hot country’ are memories of facts that have been learned at some earlier time. Tulving described episodic memory as a kind of mental diary. Episodic memory receives and stores information about experiences or events that occur at a time in our life. These memories are linked to time and context.

**Time referencing:** Tulving believed that episodic memory was dependent on time-referencing: memories about events that happened to you are linked to the time in which they occurred. For example, recalling your first day at school is linked to the date this event occurred. However, semantic memory was detached from any temporal link, as factual information could be recalled without reference to when it was learned. For example, you can recall that Paris is the capital city of France without remembering when and where you learned that fact.

**Spatial Referencing:** Input into episodic memory is continuous, as we experience a whole episode in some temporal frame of reference, such as experiencing a birthday party, whereas semantic memories can be input in a fragmentary way. We can piece factual information together that has been learned at different points in time; for example, you may learn that Emmeline Pankhurst formed the Women’s Social and Political Union in 1903, and later learn that Emily Davison is thought to have thrown herself under the hooves of the king’s horse on Derby Day. Both pieces of information can be stored independently and pieced together in a temporal form later on to understand key events in the suffragette movement.

**Retrieval:** Recall of episodic memory is dependent on the context in which the event was initially learned or experienced. It is this context that aids the retrieval of episodic memories. However, semantic memory does not seem to be dependent on the context in which it is learned, so it assumed that retrieval of semantic memories is similarly not dependent on context to aid recall. Retrieval from semantic memory can be based on inferences, generalisation and rational, logical thought. Retrieval from semantic memory leaves the memory trace relatively unchanged from its original form, so we can recall a fact without interfering with that knowledge. However, Tulving believed that episodic memory was susceptible to transformation

**Are the stores interrelated?** Semantic memory can operate independently of episodic memory. For example, we do not need to remember a classroom lesson about equations to be able to use the equations we learned. However, episodic memory is unlikely to operate without semantic memory as we need to be able to draw on previous knowledge of objects, people and events that occur in order to understand them. Tulving argued that, despite this and although the two systems may overlap, they can be treated as separate independent storesre the stores interrelated.

Summary of the differences between semantic and episodic memory

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|  | Semantic memory | Episodic memory |
| Nature of memory | Mental encyclopedia | Mental diary |
| Time referencing | Independent of time referencingInput can be fragmentary | Time and context referencedInput is continuous |
| Retrieval and forgetting | Retrieval possible without learningNot cued retrieval | Retrieval using cues which are encoded at the point of learning |
| Forgetting | Memory trace more robust and less susceptible to transformation | Forgetting due to retrieval cue failure Memory trace can be transformed/ changed |

**EVALUATION**

**Brain Damage**

Evidence for the dissociation between semantic and episodic memory suggests that one store can be affected without affecting the other one. Amnesia patients are rich sources of information. Ostergaard (1987) described a case of a 10-year-old boy with brain damage following an anoxic episode. Although his intelligence was intact, he suffered impairment to both his episodic and semantic memory. However, he did make educational progress and could store information in semantic memory. This offers some evidence for the independence of the two memory systems as Tulving suggested.

Support for the nature of episodic and semantic memory as separate long-term storage systems is also derived from case studies of KC (1951–2014). Following a serious motorbike accident, KC suffered specific long-term memory impairment to his episodic memory resulting in an inability to form or recall many personal events in his life; however, his recollection of factual information was intact. This case study supports the distinction between the two long-term memory stores and indicates possible regions of the brain where the different types of memory are stored.

Examining case studies of brain-damaged patients also points out a weakness in the model of long-term memory proposed by Tulving. Henry Molaison and Clive Wearing both suffered memory impairment that affected their ability to retain and recall long-term memory from episodic storage. However, both men were still able to remember how to perform tasks, such as playing the piano, and could still learn new skills. This points to a further long-term store for remembering practised skills. Tulving (1985) outlined this additional store in subsequent reformulations of his idea, adding PROCEDURAL MEMORY for skills and abilities that we learn, such as learning the grammatical rules of language, or riding a bicycle.

A significant problem with describing long-term memory in terms of two separate systems is that it does not account for any interrelationship or continuity between each system. Clearly they work together when given an episodic memory task, such as learning a list of words, as a word can have a semantic feature (meaning of the word) and an episodic reference (when and where the word was remembered). This makes research into the separate stores problematic because they cannot be studied in absolute isolation from one another.

Additionally, experimental studies of learning word lists are problematic as evidence for either semantic or episodic memory because they do not take into account the ‘guesses’ that participants may make when recalling the list. If a participant makes an informed guess about a word that could have been on the list of words to remember, this would represent recall from semantic, not episodic, memory. The likelihood of semantic recall in an episodic memory test is high, which means that testing the separate stores independently becomes problematic.

**RECONSTRUCTIVE MEMORY (BARTLETT, 1932)**

Sir Frederic C. Bartlett (1886–1969) was one of the most influential cognitive psychologists of the last century; his most notable contribution was a collection of memory experiments published in his book Remembering. Contrary to much experimental research at the time, Bartlett insisted on representing memory in a real context. He stated that experiments should not just capture reactions, they should capture human beings. Bartlett believed that memory should not be divided into its constituent parts and treated as independent from other functioning, but rather should be studied in a special way to capture the relationship between memory and other cognitive processes.

**Perception:** Bartlett believed that to study memory, we must first understand what precedes it and what follows it. To understand perception as a precursor to what is remembered, Bartlett devised a series of experiments to test memory for shapes and objects. He found that participants o­ften assigned verbal labels or names for each shape or object that they saw and that these names o­ften shaped the representation of the object drawn a­fterwards. He concluded the perception of the shape or object determined how it was remembered.

**Imaging:** To understand what is remembered, Bartlett conducted a series of tests on imaging, as what is remembered is what is first imaged. Using ink blots, he asked participants to describe what they imaged in the pattern they saw. He noticed that participants o­ften ‘rummaged about’ their own stored images to find one that would best fit the ink blot pattern they saw. O­ften describing the blot as a plant or animal, Bartlett suggested that the descriptions given were largely determined by the individual’s own interests and experiences, and even the mood that they were in at the time. He coined the term ‘effort a­fter meaning’ to describe how participants spent considerable effort in trying to connect a stimulus that they are given with some knowledge or experience they possess. Once the stimulus gains meaning for the individual, it can be more readily assimilated and stored. Perception is not simply the passive process of receiving an image, but an active construction of what we think we see using prior knowledge to guide the judgement. In Bartlett’s follow-up experiments on memory, he employed the same philosophy to his research, moving away from artificial laboratory investigations and the use of ‘non-sense’ or random letters and words. Instead he used images of faces and stories that participants were required to describe or repeat. In his most famous experiment, Bartlett asked participants to read and recall a North American folk tale called ‘The war of the ghosts’.

**Remembering:** Bartlett chose this folk tale for four reasons: it was culturally unfamiliar to participants so he could examine the transformations that the story may make when reproduced by participants, it lacked any rational story order, the dramatic nature of the story would encourage visual imaging, and the conclusion was somewhat supernatural and Bartlett wanted to see how participants would perceive and image this.

Each participant read the story twice and repeated reproduction was used to test the effect of time lapse on recall. Bartlett was interested in the form that the reproduced story would take, particularly a­fter repeated reproductions. Twenty participants recalled the story a­fter several minutes, weeks, months, and years; the longest time lapse was six and a half years. Bartlett found that the story became considerably shortened because of omissions made, the phrases used reflected modern concepts, and the story became more coherent in form. Several transformations to the story were reported, particularly objects within the story were made more familiar – ‘canoe’ was changed to ‘boat’, ‘hunting seals’ changed to ‘fishing’. Many participants did not grasp the role of the ghosts in the story, so simply omitted to mention them or rationalised their presence in some way. Bartlett concluded that memory is reconstructed each time it is recalled. It is rarely accurate, and is prone to distortion, rationalisation, transformation and simplification. Even recall a­fter several minutes elicited errors in recall, and these errors tended to be consolidated in subsequent reproductions. The process of remembering is constructive in nature and influenced by inferences made by an individual.

**A theory of memory:** Based on the numerous experiments he conducted, Bartlett proposed a theory of reconstructive memory. Rather than viewing memory as a passive and faithful record of what was experienced, he viewed memory as constructive in nature. He proposed that previous knowledge was used to interpret information to be stored and to actively reconstruct memories to be recalled. Rather like using a note pad, to remember something, we interpret an event and make brief notes on it. When it comes to recalling the event we actively draw on past experiences to reinterpret the notes, fill in the gaps and transform it into a coherent story. It is an imaginative reconstruction of events. Bartlett drew on the concept of schema to explain this.

**Schema Theory:** Schemas are parcels of stored knowledge or a mental representation of information about a specific event or object. Every schema has fixed information and variable information. For example, a schema for going to a restaurant would contain knowledge of fixed events, such as being waited on, choosing from a menu, eating and paying for the meal, and variable events, such as what was on the menu and how much the meal cost. Bartlett argued that we do not remember all that we perceive. We therefore draw on our schema when we recall an event to fill in the gaps. This means that recall is an active reconstruction of an event strongly influenced by previously stored knowledge, expectations and beliefs. Schemas are also used in recognition and interpretation of unfamiliar objects and events. This can explain the ‘mental rummaging’ Bartlett’s participants experienced when trying to find meaning in the ink blots: effort a­fter meaning (the effort we put into trying to find the correct schema that offers some meaning to an object).

**EVALUATION**

Bartlett based much of his research on story and object recall, but some have criticised his use of ‘The war of the ghosts’ story for having little relevance to everyday memory, and being a deliberate attempt to orchestrate evidence for his schema theory. However, Bartlett conducted his repeated reproduction experiments using eight different stories on different participants and found the same overall general shortening, transformation, familiarisation and omission. He also found similar effects on repeated and serial reproduction of pictures. Therefore, it can be argued that memory for any type of story or object is subject to the same memory errors. Bartlett believed that schema had an effect at the recall stage of memory. That is, we actively reconstruct our memory when it is retrieved, and this retrieval process is affected by the schema we possess. However, others argue that sometimes schema have an influence at the point of learning because we draw on schema to comprehend a situation and make inferences about it.

A further criticism levelled at Bartlett is the overstatement of memory as inaccurate and flawed. This has led to a wealth of experimental research to demonstrate that eyewitnesses are unreliable when recalling witnessed events. Although we should maintain caution when using eyewitness testimony as a sole source of evidence in criminal cases, Steyvers and Hemmer (2012) argue that the experimental conditions of such research deliberately induce errors in recall; leading to the view that memory is unreliable. Their research demonstrates that in a real context without manipulated material, schematic recall can be very accurate. Therefore, we should be cautious when assuming that eyewitness memory is completely unreliable.

**INDIVIDUAL DIFFERENCES IN MEMORY**

Memory has been examined so far in terms of general theories that account for the majority of people. However, it should be acknowledged that there are individual differences in memory that make us unique. The speed at which we can process information differs between individuals. This is known as ‘processing speed’. You may have noticed that some people take longer to write notes from the white board than others in your class. This is likely to be due to the speed at which they can process information and their short-term store capacity. Processing speed and capacity is affected by age too. Younger children have a shorter digit span than older children, suggesting that memory capacity increases with age. This evidence can be found in the study by Sebastián and Hernández-Gil, 2012.

**Schemas and autobiographical memory (episodic memory):** Bartlett’s reconstructive memory theory suggests that we all have relatively similar schemas, but that these schemas can be heavily influenced by experience. This in turn affects the way we perceive information received by the senses and retrieve information held in memory. A teacher, for example, may perceive a simple cylindrical drawing as being a writing implement such as a pen, whereas a child may perceive it as an arrow or a drumstick. This experience-based perception will affect how the object is remembered. Similarly, the development of our schema will affect how we recall information.

It is also true that episodic memory is individual to the person as it is a collection of memories of their own life; an autobiography of personalised events. There are individual differences in autobiographical memory. In a large-scale investigation of 598 volunteer participants, Daniela Palombo and her colleagues (2012) conducted a Survey of Autobiographical Memory (SAM) designed to assess individual differences in naturalistic autobiographical memory. Using a design more commonly associated with measuring personality, they subdivided autobiographical memory into four domains: episodic memory (memory for events), semantic memory (memory for facts), spatial memory and prospective memory (imagination for future events). The questionnaire contained 102 items which participants scored on a five-point Likert Scale.

The findings suggested that the individuals who scored high or low on episodic memory also scored high or low on semantic memory. So we either have a good or poor memory overall. Palombo et al. also found that men scored higher on spatial memory; this finding is consistent with other research indicating that men have stronger spatial ability than females. They also found that people who self-reported having depression scored low on episodic and semantic memory.

This survey gives a useful insight into self-reported accounts of naturalistic memory that could not be captured under laboratory conditions, and a useful insight into individual differences in autobiographical memory. However, it is possible that participants made inaccurate self-appraisal or lacked the insight to make accurate judgements of their own memory performance.

**DEVELOPMENTAL PSYCHOLOGY IN MEMORY**

Developmental psychology is a branch of the subject that investigates what happens to us as we age. Developmental psychology is concerned with both normal and abnormal behaviour as we grow up. For example, it is interested in how and when children learn language, but also when and why children may fail to learn language as they are expected. In memory research, dyslexia and Alzheimer’s disease have been investigated in young and old participants.

**DYSLEXIA :** Dyslexia is a reading disorder defined as a problem in learning to recognise and decode printed words at a level that would be expected for the individual’s age. This means that children with dyslexia find it difficult to read fluently and accurately, but have normal levels of comprehension (understanding). Dyslexia affects between 3 and 6 per cent of children (some estimate as many as10 per cent) and is more prevalent in boys than in girls. It is characterised by having a difficulty with phonology which is critical for learning to read. The first indication of dyslexia is showing difficulty learning letter sounds and names, indicating a problem with learning to associate a word with its speech sound. This consequently leads to spelling and reading problems.

Children with dyslexia have a poor verbal short-term memory. Evidence for this comes from the phonological similarity effect (difficulty in remembering similar sounding words) and the word length effect (difficulty remembering sequences of long words compared to short words). So perhaps it is that children with dyslexia have an impaired short-term memory to deal with speech sounds.

McDougall et al. (1994) divided 90 children into three different reading ability groups: poor readers, moderate readers and good readers, and found that poor readers had significantly lower memory spans for words and slow reading rate. Good readers can articulate words quickly, leading to a greater number of words being represented phonologically in short-term memory. Poor readers sound out words more slowly, leading to fewer words being held in short-term memory. This basic inefficiency in phonological processing and storage may explain dyslexia.

Alloway et al. (2009) suggest that children with dyslexia have difficulty in processing and remembering speech sounds because of poor working memory. They cannot hold all the speech sounds for long enough in working memory to be able to bind them together to form a word. They simply do not have the working memory capacity to store syllables for long enough to form them into a fluent word. Investigating 46 children, aged 6–11 years, with reading disability, she found that they showed short-term working memory deficits that could be the cause of their reading problems.

Similarly, Smith-Spark et al. (2010) found that adults with dyslexia had unimpaired spatial working memory, but impaired verbal working memory, compared to a control group of non-dyslexic participants. They suggest that their results indicate a deficit with the phonological loop in dyslexic participants.

Research seems to conclude quite strongly that children and adults with dyslexia have an underlying cognitive impairment leading to a shorter memory span and difficulty processing and storing verbal information in short-term memory. However, it is difficult to establish exactly what role verbal memory plays in causing dyslexia, particularly because people with dyslexia present a range of sensory impairments in both the auditory and visual systems. Additionally, dyslexia is comorbid with other learning difficulties, in particular attention deficit hyperactivity disorder and other specific learning impairments. The interaction between dyslexia and other related difficulties makes it difficult to isolate phonological issues as a reason for reading impairment

**ALZHEIMER’S:** Alzheimer’s disease is a progressive, degenerative, neurological disorder associated with ageing that will affect around one in twenty people, although the risk of development increases with age. It is the most common form of dementia and typically occurs after 65 years of age, but can occur as early as40 years old. Alzheimer’s is characterised by memory loss, concentration loss, confusion, and changes in mood that progressively become worse. The normal ageing processes result in a loss of general cognitive functioning, but Alzheimer’s disease appears to selectively impair certain cognitive systems rather than deteriorating cognition globally.

Alzheimer’s initially deteriorates the memory system for new events and information whereas older information is preserved. It also affects working memory; central executive functioning becomes impaired, making complex tasks more difficult to coordinate, and visuospatial processing becomes impaired.

A major characteristic of Alzheimer’s disease is the inability to recall autobiographical information from episodic memory, thus it affects both short-term and long-term memory recall. The extent of the memory loss is associated with the depletion of brain matter, particularly in the hippocampus and temporal cortex. The greater the brain damage, the more significant the impairment; typically this increases with progression of the disease.

Loss of executive functioning results in a lack of general coordination and difficulty with attention. Baddeley et al. (2001) conducted a series of attentional tests on individuals with Alzheimer’s and control participants, one involving looking for the letter ‘Z’ among easy and di\_ cult distractor letters (letters that either looked like the letter Z or not), and a dual task procedure. They found that patients with Alzheimer’s performed worse on the di\_ cult distractor task and were even more impaired on the dual task. This suggests that dual attentional tasks are specifically impaired by the disease.

**KEY STUDY: THE INFLUENCE OF ACOUSTIC AND SEMANTIC SIMILARITY ON LONG-TERM MEMORY FOR WORD SEQUENCES (BADDELEY, 1966)**

Baddeley wanted to test whether long-term memory and short-term memory were different or whether the emergent view of the time that memory existed on a continuum was accurate. However, investigations into short-term and long-term memory employed different research techniques, and Baddeley suggested that it would be impossible to tell whether short-term and long-term memory were different or the same unless the same research techniques were used on both. He set out an investigation to explore the effects of both semantic and acoustic coding in both long-term and short-term memory.

AIM: To investigate the influence of acoustic and semantic word similarity on learning and recall in short-term and long-term memory.

PROCEDURE: A laboratory experiment was designed to test sequential recall of acoustically and semantically similar word lists. Three different experiments were conducted, but here we will focus on experiment three.

Experiment three

Four lists of 10 words were used:

**•** List A contained 10 acoustically similar words (man, can, cat, map, etc.)

**•** List B contained 10 acoustically dissimilar words that were matched in terms of frequency of everyday use to List A (pit, few, cow, mat, etc.)

**•** List C contained 10 semantically similar words (great, large, big, broad, etc.)

**•** List D contained 10 semantically dissimilar words that were matched in terms of frequency of everyday use to List C (good, huge, deep, late, etc.)

**•** List B and D acted as baseline control groups for List A and C.

The participants were men and women recruited from the Applied Psychology Research Unit subject panel and were assigned one of the four list conditions as an independent groups design.

Each list of 10 words was presented via projector at a rate of one word every three seconds in the correct order. After presentation the participants were required to complete six tasks involving memory for digits. They were then asked to recall the word list in one minute by writing down the sequence in the correct order. This was repeated over four learning trials. As it was not a test of learning words, but a test of sequence order, the word list in random order was made visible on a card in the room. After the four learning trials, the groups were given a 15-minute interference task involving copying eight digit sequences at their own pace. After the interference task participants were given a surprise retest on the word list sequence.

|  |  |  |  |
| --- | --- | --- | --- |
| Hearing test | Learning trials | Interference task | Retest |
| Listening and copying each word presented in random order from the list | Trial 1Visual presentation of list followed by a 6 eight-digit sequence recall task, followed by recall of the list. | Trial 2Visual presentation of list followed by a 6 eight-digit sequence recall task, followed by recall of the list. | Trial 3Visual presentation of list followed by a 6 eight-digit sequence recall task, followed by recall of the list. | Trial 4Visual presentation of list followed by a 6 eight-digit sequence recall task, followed by recall of the list. | Copying sequences of digits | Recall of the word list in the correct order. |

RESULTS of experiment 3

Recall of the acoustically similar sounding words was worse than the dissimilar sounding words during the initial phase of learning (trial two in particular). However, recall of the similar and dissimilar sounding words was not statistically significant. This demonstrates that acoustic encoding was initially difficult, but did not affect long term memory recall. Participants found the semantically similar words more difficult to learn than the semantically dissimilar words and recalled significantly fewer semantically similar words in the retest.

CONCLUSION: The fact that participants found it more difficult to recall list one in the initial phase of learning suggests that short-term memory is largely acoustic, therefore acoustically similar sounding words were more di\_ cult to encode. Later retest recall of list three was impaired compared to all other lists because they were semantically similar, suggesting that encoding in long-term memory is largely, but not exclusively, semantic.

EVALUATION

Laboratory research, such as this, employs the use of experimental techniques that are not typical of the way in which we use memory in an everyday context; we do not often learn lists of random monosyllabic words. Therefore the ability to generalise these findings to everyday contexts is questioned. However, memory researchers would argue that in order to understand memory we need to remove the context in which normal memory is used and simplify the nature of the to-be learned information in order to isolate the aspects of memory we are concerned with.

This experiment relied heavily on the role of rehearsal during the four learning trials in order for information to become established in long-term memory. The very concentrated nature of rehearsal is likely to have exaggerated this memory process with the result found being an artefact of the experimental procedure. Under normal conditions we would not be expected to use rehearsal in such a contrived way, so this study lacks mundane realism. However, the study was scientific in that it was conducted in a controlled laboratory environment with a standardised procedure. Therefore the study can be regarded as replicable and the reliability of the results can be established. Due to the highly controlled nature of the experiment, Baddeley can also establish a cause and effect relationship between the independent variable (semantic or acoustic word list similarity, and the dependent variable (long-term memory

**KEY STUDY: Sebastián and Hernández-Gil’s (2012) study of the developmental pattern of digit span**

Working at the University of Madrid, Mariá Victoria Sebastián and Laura Hernández-Gil examined the developmental pattern of digit span in the Spanish population to test the phonological loop component of working memory (Baddeley and Hitch, 1974). They set out to investigate the capacity of the phonological loop to understand whether it would differ in a Spanish population across different ages. Anglo-Saxon research concluded that digit span increased with age, so Sebastián and Hernández-Gil wanted to see whether the same developmental trend occurred in a different culture to assess whether Anglo-Saxon findings could be generalised using the same digit span procedure.

**AIMS**: To investigate the development of the phonological loop in children between the ages of 5 and 17 years using digit span as a measure of phonological capacity. They also wanted to compare the findings to their previous research of adult, aged and dementia patients.

**PROCEDURE:** A sample of 570 volunteer (or volunteered) participants were taken from schools in Madrid. All participants were native Spanish and impairments in hearing, reading and writing ability were controlled. Participants were divided into five different age groups and the average digit span was recorded for each age and age group. Tested individually, participants were read increasing sequences of digits to recall in the correct order.

The digits were read out at a rate of one per second and the digit list increased one digit per sequence. The digit span for participants was recorded as the maximum digit recalled in the correct order without error.

**RESULTS**: The table shows clearly a developmental trend of increasing digit span with age. Children aged 5 years have a very low digit span that rises steadily until around 11 years old where it slows. The digit span between 15 and 17 years remains fairly stable.

Comparing the findings to previous research

Comparing the findings of this study to previous related research conducted by Sebastián and Hernández-Gil, they found that elderly participants had a significantly higher digit span compared to the 5-year-olds in this study, but it was not significantly different from other age groups. Patients with advanced dementia (AD) showed a similar profile (mean digit span 4.2). However, patients with frontal variant frontotemporal dementia (fvFTD) had a digit span that was significantly similar to the younger age group. Comparing the elderly group to the dementia patients showed no significant difference, suggesting that impoverished digit span was a consequence of ageing rather than dementias.

Consistent with Anglo-Saxon research, this investigation showed a continued increase in digit span over time in the Spanish population. However, the overall capacity of digit span was far lower in the Spanish population compared to the digit span of seven found in Anglo-Saxon studies. This decrease in phonological capacity could be accounted for by the nature of the Spanish language. Digits in Spanish tend to be two or more syllables (e.g. uno, cuatro, cinco, ocho), compared to the monosyllabic Anglo-Saxon numerals (e.g. one, two, three, four). This word (or digit) length effect means that it takes more time to sub-vocally repeat and rehearse Spanish words, taking up more space in the phonological loop, resulting in a lower digit span. To further support the word length effect as an explanation for the difference in digit span, differences at each age was examined. As sub-vocal rehearsal does not appear until the age of 7–8 years, there should be no difference in digit span as a result of word length effect until after this age. This was found to be true as, before the age of 7 years, differences between Spanish and Anglo-Saxon counterparts were not found. At age 9 years, there is a noticeable difference in digit span, suggesting that word length effect occurs once sub-vocalisation appears in phonological development. However, unlike previous research, this study speculates that digit span in the Spanish population increases beyond the age of 15 years.

**CONCLUSIONS**: Digit span was found to increase with age; the starting point of this development occurs when children are able to sub-vocalise at around 7 years. Digit span in the Spanish population is significantly shorter than Anglo-Saxon culture, probably due to the word length effect associated with digits. Comparing the findings to research into patients with degenerative neurological disease and the aged population, it is possible to speculate from this research that poor digit span is a result of ageing rather than dementias.

**EVALUATION:** Digit span experiments are measures of the phonological loop proposed by Baddeley and Hitch (1972). However, we rarely use verbal memory to memorise lists of digit in everyday life, other than when trying to rehearse a telephone number. Everyday verbal memory is used to hold sequences of words in order to comprehend sentences, master new languages or aid reading of complex information. Therefore it is open to question whether or not digit span experiments reflect everyday use of verbal memory. However, digit span tests have been reliably linked to performance in reading ability and intelligence, suggesting they are a good general measure of verbal memory. Digits, rather than word sequences or sentences, are also considered to be a culture-free and meaning-free way of measuring pure verbal memory. However, based on the cultural differences found, digits may not be the best culture-free determinant of verbal memory capacity. Cultural differences in digit span have been reported by other researchers. Ellis and Hennelley (1980) reported poorer digit span in Welsh-speaking children compared to English children, largely because Welsh words for digits take longer to pronounce than English digit words. Longer digit spans have been reported in Chinese because the words for digits are short (Stigler et al., 1986). This research supports the finding that language and the phonological loop are interrelated. A large sample size was tested in this study, allowing the findings to be considered reliable and generalisable to the Spanish population as a whole. The sample size gathered was important for this research because comparisons were made across different cultures. The study also excluded participants with any hearing, reading or language impairments, known to diminish digit span, which could have affected the results.

**KEY QUESTION**: **How can knowledge of the working memory be used to inform the treatment of dyslexia?**

Dyslexia is a reading disorder associated with poor or inefficient working memory. Children with dyslexia ﬁnd it difficult to hold enough information in working memory to be able to blend sounds to form a word and ﬁnd associating letters to sounds problematic. This results in slower reading and writing ability. They have particular phonological deﬁcits too, meaning that they code phonology inefficiently in the brain, causing problems with short-term verbal memory such as difficulties with non-word repetition, rapid naming and learning a new language. Ultimately, the memory problems associated with dyslexia mean that skills associated with reading, writing, spelling and grammar are impaired. These difficulties are often detected during preschool and early year’s education, and a number of classroom strategies have been identiﬁed in order to help students with dyslexia.

**Interventions based on working memory:**There are currently two main interventions used to help children with dyslexia in schools. One is a classroom-based approach that aims to alter the teaching and learning environment to better suit children with working memory problems. These classroom strategies are easy to implement by educators and can be used with all children to aid learning. The second is direct intervention to help children with literacy difficulties to improve their working memory. There are several types of direct intervention programmes, but all aim to help children practise and develop working memory using speciﬁc or a variety of tasks targeted at increasing processing speed and strategies for remembering.

**Classroom strategies approach:** Strategies used in the classroom to help children with dyslexia include:clearly stating lesson aims, using checklists**,** simplifying instructions**,** highlighting or colour coding information**,** using audio and visual materialsand avoiding asking a child to read out loud.

By simplifying and breaking down classroom tasks it avoids overloading the limited working memory capacity associated with dyslexia. Dyslexia is also associated with slower processing speeds, avoiding lengthy periods of teacher talking and using alternative delivery methods can work better to prevent phonological loop overload.

Spelling can be difficult for a child with dyslexia because they ﬁnd it hard to associate a letter sound with the printed letter. Phonics is a literacy strategy that uses phonological rules to learn letter sounds and encourages sound blending. Mathematics can also be difficult for a child with dyslexia because they are required to take different steps to solve a mathematical problem, which can overload working memory. Each arithmetic step can be written down or verbally discussed to ensure that it is broken into stages.

**Direct intervention programmes:** Different intervention strategies have been designed to help children with literacy difficulties in schools by directly targeting memory skills. Some of these interventions are computer based and target a range of working memory skills, such as Cogmed, or target speciﬁc memory skills, such as the N-Back programme (Klingberg et al., 2005; Jaeggi et al., 2011). These programmes have been shown to enhance working memory with long-lasting cognitive gains and academic improvement in both Maths and English.

**Are interventions effective?**

In a review of dyslexia interventions, Snowling and Hulme (2011) commented that for dyslexia interventions to work there should be targeted training in phonological awareness, letter-sound recognition, and practice in reading and writing. However, children present different literacy difficulties, so it impossible to implement a ‘one ﬁts all’ strategy. They also highlight that there is currently a delay in diagnosing literacy difficulties, which can sometimes be mistaken for attention problems, making early intervention difficult.

Dyslexia, like many learning impairments, can cause social and emotional difficulties, such as a loss of self-esteem and conﬁdence. These aspects of the condition are not treated in intervention programmes per se, but should be addressed as much as memory enhancement techniques because they may not naturally recover with working memory improvements.

In conclusion, the evidence so far suggests that there are cognitive beneﬁts shown from both classroom-based and direct intervention strategies, particularly early interventions; however the long-term gains and transferability of these beneﬁts to daily tasks and activities is questionable.