

The Effectiveness of Visual and Auditory Memory

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Abstract

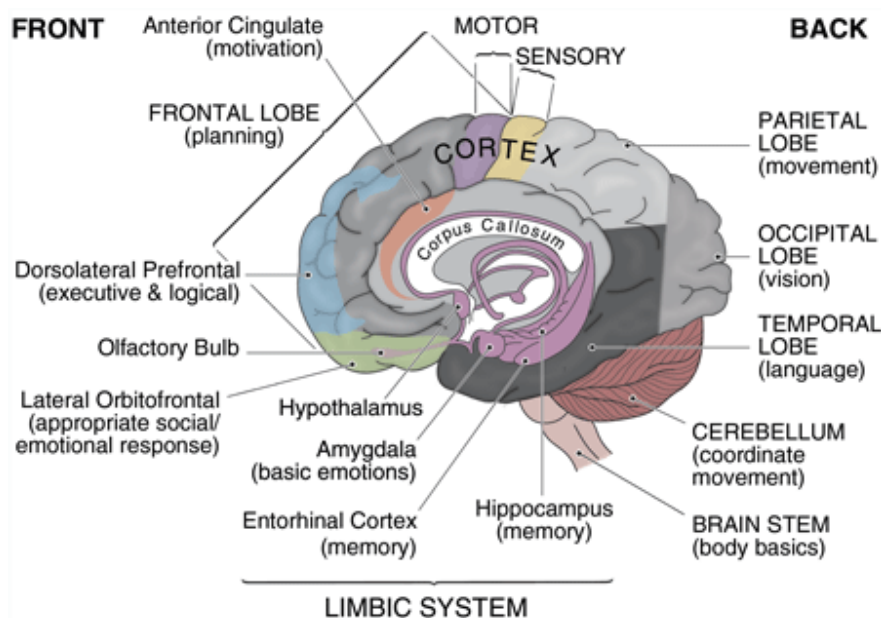
News reports are a common part of living in today's society, but what form of news is the most effective and memorable? Information is endlessly presented to you and it is important to understand what form to present this material in to others so that the likelihood of them remembering it is much higher. The brain processes information using electrical impulses, neurons, neurotransmitters and synapses. Memories are created in three main steps; encoding, consolidation and memory retrieval. This report aims to determine the effect of different ways of presenting information on the score in a memory recall test. It was hypothesised that information would be most effectively remembered when presented with both audio and visuals. 40 test subjects were selected to participate in an immediate memory recall test in which they had to remember as many words as possible from the three 10-word lists presented to them by three different means (visual, audio, audio/visual). The lists were presented in the form of a video which was shown on a laptop screen in a quiet, well-lit room. From the results, it was concluded that visual information is recalled the most effectively, followed by audio/visual and then audio information.

Background Research

Introduction

The brain is part of the Central Nervous System (CNS) along with the Spinal Cord. The CNS receives and sends out messages in order to control the body. The Peripheral Nervous System consists of nerves and sensory receptors which send messages to the brain about conditions and also carries messages back to effector organs. These messages (in the form of electrical impulses) pass through the body via nerve cells called neurons. Neurons have unique features, different to other cells. These are called axons and dendrites. Axons carry information away from the cell and dendrites receive information. Nerves are groups of neurons. The brain has 25 billion neurons, each of which are connected to up to 1000 others. The gaps between neurons where electrical impulses are sent are called synapses and there are around 100 million million synapses in the brain. The brain consists of three parts - the Cerebrum, the Cerebellum and the Medulla. The cerebrum controls thoughts, memory, muscle control and the senses. The cerebellum controls complex muscular movements and the medulla controls unconscious activities e.g. breathing.

Diagram of the Brain



Building Mental Muscle. 2013. Your Brain and What It Does. [ONLINE] Available at: <http://www.brainwaves.com/>. [Accessed 10 February 14].

Memories are created when nerve cells in a circuit increase the strength of their connections, known as synapses. In the case of short-term memories, the effect lasts only minutes to hours. For long-term memories, the synapses become permanently strengthened (Fields 2005, p. 74-81).

Encoding

Encoding is the first step that your brain takes to make a memory. It is based around perception through the senses (using the primary sensory areas of the cerebral cortex as well as the associative areas and the entorhinal and rhinal cortexes). You must be paying attention for a memory to be encoded properly (regulated by the frontal lobe and the thalamus), which means not every single experience is encoded. Emotion normally increases attention and the emotional elements of a memory are processed unconsciously in the amygdala (located in the medial temporal lobe). When you use your senses, the information travels on an anterograde pathway to one central area called the hippocampus (which is located in the medial temporal lobe). The hippocampus makes you understand that these occurrences are from one single experience and “decides” whether to put these experiences into your long-term memory. It is not entirely proven how this process works but scientists suggest that it is by comparing the current experience to similar previous events. Information destined for what is known as declarative memory--people, places, events--must pass through the hippocampus before being recorded in the cerebral cortex (Fields 2005, p. 74-81). Other pathways, called retrograde pathways, lead away from the hippocampus back to the primary cortexes. After this, the different threads of information are stored in different areas of the brain. It is not yet proven how the brain recalls all of the threads of information from different areas of the brain later on.

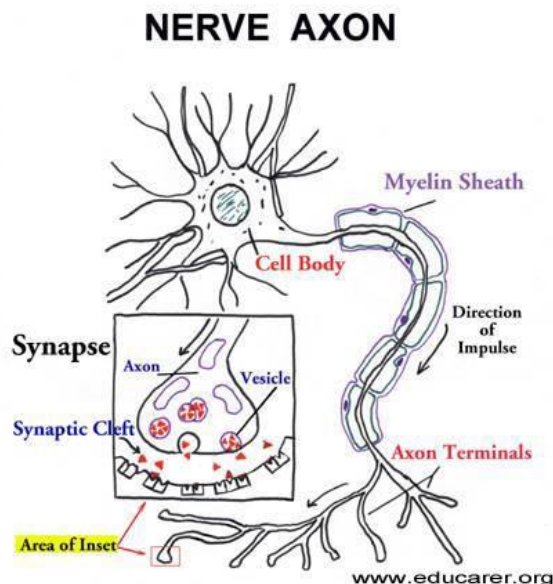
The four main types of encoding are:

- Acoustic encoding - the processing and encoding of sound, words and other auditory input for storage and later retrieval (Mastin 2010).
- Visual encoding - the process of encoding images and visual sensory information (Mastin 2010). The amygdala is an important part of visual encoding as it uses the visual information as well as other systems to install a positive or negative emotional response to condition stimuli
- Tactile encoding - The encoding of how something feels, normally through the sense of touch (Mastin 2010).
- Semantic encoding - the process of encoding sensory input that has particular meaning or can be applied to a particular context (Mastin 2010).

Short-term memory mainly uses acoustic encoding and long-term memory uses semantic encoding. The brain is mostly associative which means that every new experience is remembered better if it can be associated with previous experiences in the long-term memory.

Memories are encoded and stored using chemicals and electricity. The electrical pulses across synapses in the brain trigger neurotransmitters which diffuse across the space between the cells and attaching to nearby cells. One neuron's signal-emitting extension, called an axon, meets any of an adjacent neuron's dozens of signal-receiving fingers, called dendrites. This triggers a local depolarization of the other (postsynaptic) cell's membrane (Fields 2005, p. 74-81). In a memorable event,

neurons are fired more frequently which increases the likelihood that the event is encoded. Brain cells organize into specialized groups depending on the sort of information they process. The synapse between two brain cells become stronger the more they send signals to each other which means the brain rewires it's physical structure with each new experience. The more new information processed, stronger and intricate "circuits" of memory are built up.



Porter, P. 2007. EDUCARER.org WORLD OF INFANTS - ARTICLE - EARLY BRAIN DEVELOPMENT. [online] Available at: <http://www.educarer.com/brain.htm> [Accessed: 09 Feb 2014].

Memory Consolidation

The process of consolidation is when short-term memories which are dependent on the hippocampus become long-term memories independent of the hippocampus. Synapses increase in strength when the same group of neurons transmit signals to each other so regularly that they become sensitized to each other. This is also known as long-term potentiation. This is why, for example, if one studies the same topic multiple times they become better at it.

- Synaptic consolidation - within the first few hours after encoding
- System consolidation - from a few weeks to year, when the memories become independent of the hippocampus

Memory Retrieval

Re-accessing information encoded in the past involves the brain "replaying" the same neural pattern created when the experience was encoded initially. The patterns aren't exactly the same they are mixed with new information that is associated with the same memory (also known as creative reimagination). This is how we can distinguish between experiencing something and remembering something. The stronger the neural pathways, the faster it is for something to be remembered. Memory recall is very similar to the original encoding as it takes a long-term memory and brings it into short-term memory (where it can be retrieved) and then stored again in long-term, thus strengthening the neural pathways.

- Recognition - a mostly unconscious process that involves the comparison of information to associate an experience to a previous event

- Recall - the search and retrieval of candidate items from memory is followed by a familiarity decision where the correct information is chosen from the candidates retrieved (Mastin 2010).
- All neurons have to be activated and the information is reconstructed
 - Free recall - given a list and has to recall them in any order
 - Cued recall - given a list and is tested with the use of cues/guides
 - Serial recall - recalling items/events in order (e.g. events in our life, sentence structure etc.)

Serial Recall

Serial recall differs from short-term to long-term memory. In short term memory, the list is remembered as a list of singular items, and in long-term memory, the list is stored as a whole, singular memory. In serial recall, people often recall the right information but in the wrong order and if there are errors, it normally resembles the correct answer (e.g. bat instead of cat). There can also be repetition errors. The most recent events tend to be remembered easily in order. In a list, if there is a missed item, it tends to be recalled straight after the item that was recalled too early. Also, if an item from a previous list is recalled in a current trial, it is normally in the same position as it was on its original list.

Sensory memory, Short-term memory and Long-term memory

Experts say that there are three stages for storing memory - the sensory stage, short-term memory and long-term memory. Sensory memory is the ability to retain impressions of sensory information after the original stimuli has ended. (Mastin 2010) The sensory stage lasts from 0.05 to 4 seconds, it allows a perception such as a visual pattern, a sound, or a touch to linger for a brief moment after the stimulation is over. (Mohs, 2012) This information is then stored in short-term memory, but this doesn't have a large capacity - it can only hold around seven items for around 20 or 30 seconds. A synapse is temporarily strengthened and the surrounding neurons fire briefly in fast bursts. If the information is important, it is moved from short-term memory into long term memory. Long-term memory can store unlimited amounts of information indefinitely (Mohs 2012). Long term memories are stored in many different parts of the brain as groups of neurons which fire in the same strengthened pattern as the original experience. If an experience is encoded multiple times, this means that if one memory trace, or engram, is lost, there are still other "pathways" in different areas of the brain in which the memory can be retrieved.

Forgetting

If one forgets something, it is normally because of two reasons - they didn't encode the information properly because they were distracted while the encoding took place or they had trouble retrieving the memory itself. When someone forgets something, it follows a logarithmic curve, meaning that at first it is hard for one to forget, but as time passes and the pathways of synapses are less used, the memory may become "lost" when the brain continually reorganizes its neural network.

Memory vs Age

Scientists have many theories about how memory deteriorates with age but the main theory is that as you age, there is cell loss in the area of the brain which produces a neurotransmitter called acetylcholine (which is essential in the memory-creating

process). The hippocampus is also an area that experiences large cell loss (5% per decade).

Audio/Visual Recall

Audio information is interconnected serially and visual information is interconnected spatially. This means that there is a different amount of information needed to remember/recognise visual and audio experiences. In the brain, there is more visual information stored than audio which means there is more information to associate and activate memories.

Previous experiments about Audio/Visual Recall

Grimes, T. - Educational Technology Research and Development, 1990

Three versions of four TV news stories were chosen as the stimuli. The high-correspondence version employed a specific audio-video semantic match, the medium-correspondence version a less specific match, and the no-correspondence version no match (Grimes 1990, p.15-25). The channel that received the highest memory scores was the high-correspondence version. It was concluded that when attentional capacity is exceeded, memory of the overall story is degraded (Grimes 1990, p.15-25).

Fogle, H, 2012

Ten subjects were taken to a quiet area and were told to recall items shown without sound and then read out verbally. 9/10 recalled visual information more accurately.

Furnham, A. Gunter, B. Green, A. - Applied Cognitive Psychology, 2013

Two studies were carried out to test whether the audio, visual or transcript for a news report was remembered the most accurately. For both experiments, the typed text was remembered the best.

Wallman, K. - California State Science Fair 2003

The subject had 15 seconds to memorise twelve physical objects and twelve recorded objects and then had to write them down by memory. 16/24 remembered visual information better, 3/24 remembered audio information more accurately 5/24 were equal.

National Academy of Sciences USA, 2009

11 experiments were carried out with 12 participants per experiment. Each experiment had different audio and visual stimuli. It was clear from the results that auditory recognition memory performance is markedly inferior to visual recognition memory on this task (Cohen 2009, p. 6008–6010).

Glossary

The definitions of all underlined words in the text above can be found here

Anterograde

1: occurring or performed in the normal or forward direction of conduction or flow
<anterograde axonal transport>

2: affecting memories of a period immediately following a shock or seizure
<anterograde amnesia>

(Merriam Webster Online Dictionary, 2014)

Axon

A usually long and single nerve-cell process that usually conducts impulses away from the cell body. (Merriam Webster Online Dictionary, 2014)

Brain

The organ of the body in the head that controls functions, movements, sensations, and thoughts. (Merriam Webster Online Dictionary, 2014)

Central Nervous System

The part of the nervous system which in vertebrates consists of the brain and spinal cord, to which sensory impulses are transmitted and from which motor impulses pass out, and which coordinates the activity of the entire nervous system. (Merriam Webster Online Dictionary, 2014)

Cerebellum

A large dorsally projecting part of the brain concerned especially with the coordination of muscles and the maintenance of bodily equilibrium, situated between the brain stem and the back of the cerebrum, and formed in humans of two lateral lobes and a median lobe. (Merriam Webster Online Dictionary, 2014)

Cerebral Cortex

The convoluted surface layer of gray matter of the cerebrum that functions chiefly in coordination of sensory and motor information. (Merriam Webster Online Dictionary, 2014)

Cerebrum

An enlarged anterior or upper part of the brain; especially : the expanded anterior portion of the brain that in higher mammals overlies the rest of the brain, consists of cerebral hemispheres and connecting structures, and is considered to be the seat of conscious mental processes. (Merriam Webster Online Dictionary, 2014)

Dendrite

Any of the usually branching protoplasmic processes that conduct impulses toward the body of a neuron. (Merriam Webster Online Dictionary, 2014)

Effector

A bodily organ (as a gland or muscle) that becomes active in response to stimulation. (Merriam Webster Online Dictionary, 2014)

Frontal lobe

The anterior division of each cerebral hemisphere having its lower part in the anterior fossa of the skull and bordered behind by the central sulcus. (Merriam Webster Online Dictionary, 2014)

Hippocampus

A curved elongated ridge that extends over the floor of the descending horn of each lateral ventricle of the brain, that consists of gray matter covered on the ventricular surface with white matter, and that is involved in forming, storing, and processing memory. (Merriam Webster Online Dictionary, 2014)

Medulla

The 'stem' of the brain. It controls vital activities that do not require conscious thought, like breathing and heartbeat. (Science Focus 3 2010, p.132)

Neocortex

The large 6-layered dorsal region of the cerebral cortex that is unique to mammals. (Merriam Webster Online Dictionary, 2014)

Nerve

Any of the filamentous bands of nervous tissue that connect parts of the nervous system with the other organs, conduct nervous impulses, and are made up of axons and dendrites together with protective and supportive structures and that for the larger nerves have the fibers gathered into funiculi surrounded by a perineurium and the funiculi enclosed in a common epineurium. (Merriam Webster Online Dictionary, 2014)

Neuron

One of the cells that constitute nervous tissue, that have the property of transmitting and receiving nervous impulses, and that are composed of somewhat reddish or grayish protoplasm with a large nucleus containing a conspicuous nucleolus, irregular cytoplasmic granules, and cytoplasmic processes which are highly differentiated frequently as multiple dendrites or usually as solitary axons and which conduct impulses toward and away from the nerve cell body—called also nerve cell. (Merriam Webster Online Dictionary, 2014)

Neurotransmitter

Substance (as norepinephrine or acetylcholine) that transmits nerve impulses across a synapse (Merriam Webster Online Dictionary, 2014)

Peripheral Nervous System

The part of the nervous system that is outside the central nervous system and comprises the cranial nerves excepting the optic nerve, the spinal nerves, and the autonomic nervous system. (Merriam Webster Online Dictionary, 2014)

Retrograde

1: affecting memories of a period prior to a shock or seizure <retrograde amnesia>
2: occurring along nerve cell processes toward the cell body <retrograde axonal transport>

(Merriam Webster Online Dictionary, 2014)

Rhinal cortex

The cortex surrounding the rhinal fissure and is part of the neural circuit for explicit memory. Includes the entorhinal and the perirhinal cortex. (Merriam Webster Online Dictionary, 2014)

Spinal cord

The large group of nerves which runs through the centre of the spine and carries messages between the brain and the rest of the body. (Merriam Webster Online Dictionary, 2014)

Synapse

The point at which a nervous impulse passes from one neuron to another. (Merriam Webster Online Dictionary, 2014)

Thalamus

The largest subdivision of the diencephalon that consists chiefly of an ovoid mass of nuclei in each lateral wall of the third ventricle and serves chiefly to relay impulses and especially sensory impulses to and from the cerebral cortex. (Merriam Webster Online Dictionary, 2014)

Aim

To determine the effect of different ways of presenting information on the score in a memory recall test.

Hypothesis

When the information is presented with both audio and visuals, the score in the memory recall test will be higher.

Equipment List

- 1 x Laptop (school provided model - Dell Latitude E6220)
- 40 x subjects with access to a Dell Latitude E6220 laptop (20x girls aged 14-16, 10x boys aged 14-16, 5x men aged 50+, 5x women aged 50+)
- 1x Pen
- 1x Paper

Risk Assessment

Activity description: Use of laptop to make a video, email it to the subjects and carry out a simple memory test

Step 1: Identify the hazard	CSIS User code	Step 2: Strategies to minimise the hazard	Step 3: Assessment of risk (see table below)	Step 4: What if something goes wrong?	Step 5: Packing up
Laptop may cause electrocution	na	Plug laptop in securely and don't eat/drink near it, don't use if damaged	1+1=2=LOW Depending on the amount of milliamperes in the current, the maximum damage caused by electric shock is cardiac arrest, internal organ damage, severe burns.	Turn off source of electricity. If major electric shock occurs, don't touch the person who has been shocked, keep away from water as it conducts electricity, put them on a non-conductive surface and call 000/ treat burns if necessary	Unplug, switch off and place in case on a stable benchtop/shelf.
Damage to eyes/neck from laptop screen	na	Make sure screen is an arm's length away and positioned directly in front of face	1+1=2=LOW Eye strain, redness, irritation or dryness, a burning feeling in the eyes,	Take a break from laptop, change your posture, turn off laptop, turn down screen brightness.	Unplug, switch off and place in case on a stable benchtop/shelf.

		Position the monitor 4-8 in. below eyes. Use comfortable lighting. Take breaks every 15 minutes	blurred or double vision after computer use, headaches and neck and shoulder pain.		
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Mandatory precautions: Covered shoes, safety glasses, hair exceeding shoulder length tied back.

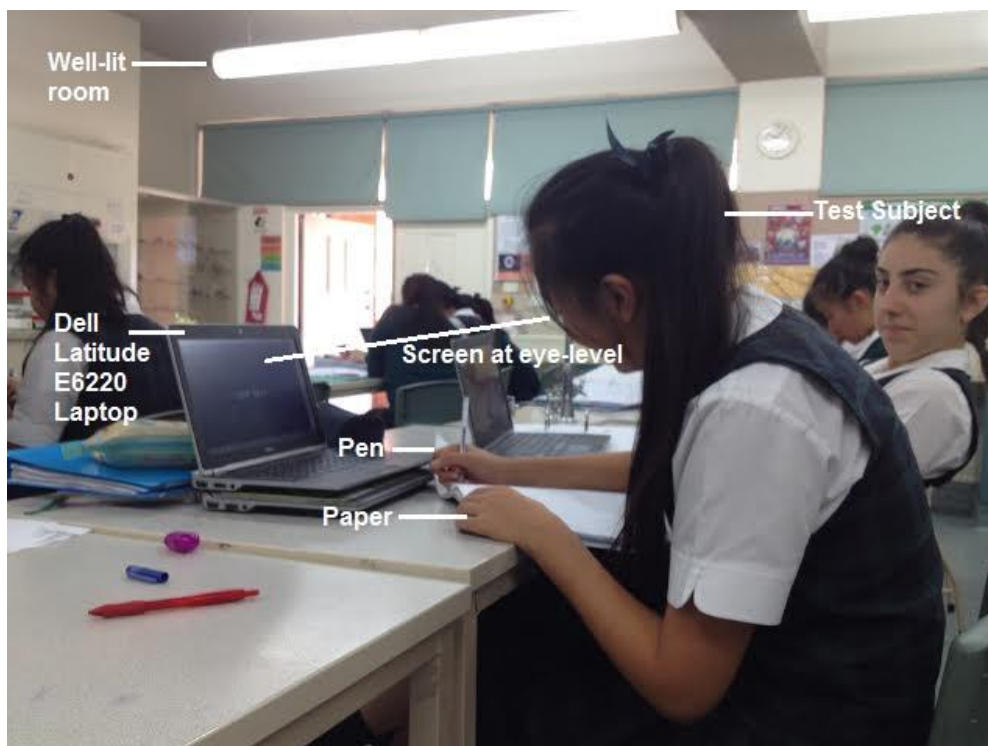
Date:

Student Signature:

Method

1. 40 test subjects were selected (by quota sample)
2. A 3-part video containing a list of 10 words (text), 10 words read out (audio), and 10 typed words with audio was created using iMovie
3. The final video was emailed to the test subjects along with instructions
4. The test subjects watched Part 1 of the video and wrote down the words in order, by memory, 15 seconds afterwards
5. The test subjects watched Part 2 of the video and wrote down the words in order, by memory, 15 seconds afterwards
6. The test subjects watched Part 3 of the video and wrote down the words in order, by memory, 15 seconds afterwards
7. The three lists that were written down were sent back to the experiment conductor by email
8. The percentage of correct answers for each test was recorded for every subject

Diagram Showing Experiment Set-Up



Lists (Words)

Words were presented at 4-second intervals

Visual

1. Book
2. Car
3. Bridge
4. Snail
5. Laptop
6. Brush
7. Shoes
8. Curtain
9. Train
10. Photograph

Audio

1. Elephant
2. Paperclip
3. Piano
4. House
5. Scissors
6. Monkey
7. Window
8. Carrots
9. Postbox
10. Pencil

Visual/Audio

1. Keyboard
2. Scissors
3. Street
4. Onions
5. T-Shirt
6. Sky
7. Saxophone
8. Rhino
9. Postbox
10. Socks

Explanation of why the method is valid for investigating the selected hypothesis

This method is valid because it controls all the variables and its system of measurement is accurate. When creating the video, the same genre of words, the same font and the same voice was used. The only thing changed in the creation of the video was the form in which the information was presented. The same video was sent to all of the subjects to ensure that they are all being tested on the exact same lists and to make sure there is only one independent variable. This method controls all other variables because in the email all the controlled variables (see below) were specified so the subjects can follow a clear, detailed set of instructions without making changes that could affect the results. The system of measurement is accurate as it is a percentage of correct answers and therefore cannot be measured

incorrectly due to human error. It was also made sure that every subject has access to a Dell Latitude E6220.

Clearly identified dependent variable, independent variable and controlled variable

Independent variable - The way the information is presented (audio, visual, both)

Dependent variable - Result in test (% of correct answers)

Controlled variables - Same "genre" of words, same model of laptop (Dell Latitude E6220), same video sent out, same audio volume, same voice for audio, same brightness, same font of text, played in full screen, screen at eye-level, same environment (quiet, well-lit room)

How were the controlled variables maintained throughout the experiment?

When creating the video, the same genre and list of words were used and the exact same video was sent to each subject via email. The other specifications - model of laptop, volume of laptop, brightness of laptop, environment and played in full screen was stated in the email and the subjects followed the instructions specified.

Timeline

- 1st February - List SRP topic ideas
- 2nd February - Decide on SRP topic and write aim
- 3rd February - Ask teacher in class if topic is suitable
- 5th February - Begin research and write equipment list and method
- 7th-13th February - Finish research and write the rest of the outline based on research
- **14th February - Hand in SRP Outline**
- 15th-18th February - Make video
- 18th-10th March - Send out video and wait for responses
- 11th March - 16th March- tabulate and construct graphs with the data received
- 19th March - 28th March - Write discussion and conclusion, take photos
- 28th March - 4th April - Finalise document, edit, format etc.
- **4th April - Hand in SRP Report**

Results

*words in **bold** are incorrect

Table Showing the Responses from Boys

	Visual	Audio	Audio/Visual
Boy 1	Book, Car, Bridge, Snail, Brush, Train,	Elephant, Pencil, Postbox, Snail , House, Paperclip	T-shirt, Postbox, Shoes , Paperclip , Scissors, Pencil Case
Boy 2	Book, Car, Bridge, Snail, Laptop, Brush, Shoes, Train	Paperclip, Elephant, Monkey, Carrots, Pencil, Postbox	Keyboard, Scissors, Street, Saxophone, T-shirt, Rhino, Postbox, Socks
Boy 3	Book, Car, Laptop, Snail, Shoes, Train	Monkey, Elephant, House, Carrots, Pencil, Postbox	Street, Scissors, Saxophone, Rhino, Postbox
Boy 4	Book, Car, Snail, Laptop, Shoes, Train, Photograph	Elephant, Potato , House, Monkey, Window	Keyboard, Rhino, Painting , Microphone , Saxophone, Postbox, Socks
Boy 5	Book, Car, Snail, Bridge, Laptop, Photograph, Train	Elephant, House, Postbox, Pencil	Scissors, T-shirt, Rhino, Postbox
Boy 6	Bridge, Laptop, Shoes, Snail, Laptop, Photograph	Elephant, House, Monkey, Window, Pencilcase	T-shirt, Scissors, Rhino, Postbox
Boy 7	Book, Laptop, Snail, Train, Bridge	Elephant, Window, House, Paperclip, Scissors	Keyboard, Scissors, Onions, Street, T-shirt
Boy 8	Book, Car, Snail, Laptop, Shoes, Brush, Curtain, Train, Photograph	Elephant, Paperclip, House, Monkey, Scissors, Carrots, Postbox, Pencil	Keyboard, Scissors, Street, Onions, T-shirt, Saxophone, Rhino, Socks, Postbox

Boy 9	Book, Car, Bridge, Laptop, Snail, Brush, Photograph, Train	Elephant, Paperclip, Piano, House, Monkey, Window, Carrots, Postbox, Pencil	Keyboard, Scissors, Rhino, Street, Onions, T-shirt, Sky, Saxophone, Postbox, Socks
Boy 10	Book, Car, Bridge, Snail, Laptop, Curtain, Train	Elephant, Paperclip, House, Scissors, Carrots	Keyboard, Scissors, Sky, Rhino, Paperclip , T-Shirt, Saxophone

Table Showing the Responses from Girls

	Visual	Audio	Audio/Visual
Girl 1	Book, Car, Bridge, Snail, Brush, Train, Photograph	Pencil	Keyboard, Street, Onions, Saxophone, Rhino, Postbox, Socks
Girl 2	Book, Car, Bridge, Snail, Laptop, Train, Photograph	Elephant, Paperclip, Scissors, Monkey, Postbox, Pencil	Keyboard, Scissors, Street, Postbox
Girl 3	Book, Car, Bridge, Snail, Laptop, Shoes, Train, Curtain	Elephant, Paperclip, Piano, House, Scissors, Monkey, Postbox, Pencil	Keyboard, Scissors, Onions, Sky, Saxophone, Rhino, Postbox
Girl 4	Book, Car, Bridge, Snail, Laptop, Car , Shoes, Curtain, Train	Elephant, Paperclip, Piano, House, Scissors, Postbox, Pencil	Keyboard, Scissors, Piano , Postbox, Rhino, Socks
Girl 5	Book, Car, Bridge, Snail, Train, Photograph, Curtain	Elephant, Paperclip, Pencil, House	Keyboard, Saxophone, Piano, Rhino
Girl 6	Book, Car, Bridge, Snail, Curtain, Shoes, Train	Elephant, Paperclip, House, Monkey, Window, Carrots, Pencil, Postbox	Keyboard, Scissors, Onions, T-Shirt, Sky, Rhino, Saxophone, Socks
Girl 7	Book, Car, Bridge, Snail, Brush	Elephant, Piano, Paperclip, Scissors,	Keyboard, Scissors, Street, Onions, T-shirt, Sky,

	Train, Curtain	House, Monkey, Pencil	Saxophone, Postbox, Socks
Girl 8	Book, Car, Bridge, Telephone , Brush, Snail, Elephant , Train, Photograph	Elephant, Paperclip, Piano, House, Monkey, Scissors, Carrots, Postbox, Pencil	T-shirt, Keyboard, Scissors, Rhino, Postbox, Socks
Girl 9	Book, Car, Bridge, Snail, Photograph	Paperclip, Carrots, Pencil, Postbox	Keyboard, Scissors, Rhino, Postbox, Socks, Onions
Girl 10	Book, Car, Tree , Train, Curtain, Dog , Shoes	Elephant, Plane , Pencil, Scissors, Window, Postbox	Socks, Postbox, Rhino
Girl 11	Book, Car, Bridge, Snail, Laptop, Brush, Photograph, Train	Elephant, Paperclip, Piano, House, Monkey, Carrots, Postbox, Pencil	Keyboard, Scissors, Street, House, Sky, Saxophone, Rhino, Postbox, Socks
Girl 12	Book, Car, Shoes, Laptop, Bridge, Sawdust , Carrots	Elephant, Paperclip, House, Scissors, Monkey, Postbox, Pencil	Saxophone, Postbox
Girl 13	Book, Car, Bridge, Snail, Photograph, Train	Postbox, Pencil, Elephant, Eagle	Scissors, Piano, Postbox, Socks
Girl 14	Book, Car, Bridge, Hairbrush , Shoes, Laptop	Elephant, Paperclip, Scissors, Postbox	Keyboard, Scissors, Street, Onions, Sky, Postbox
Girl 15	Book, Car, Snail, Laptop, Brush, Train	Elephant, Paperclip, House, Monkey, Scissors	Keyboard, Scissors, Onions, Rhino
Girl 16	Book, Car, Bridge, Snail, Laptop, Curtain, Photograph	Elephant, Paperclip, Piano, House, Monkey, Window, Carrots, Postbox	Keyboard, Scissors, Street, T-Shirt, Sky, Rhino, Postbox, Socks

Girl 17	Book, Bridge, Snail, Car, Train, Book , Photograph	Elephant, Pencil, Monkey, Window, Paperclip	Keyboard, Scissors, Street, T-shirt, Rhino, Socks
Girl 18	Book, Car, Bridge, Laptop, Shoes, Curtain	Elephant, Piano, Scissors, Monkey, Postbox, Carrots	Keyboard, Scissors, Street, T-Shirt, Rhino, Postbox, Socks
Girl 19	Book, Snail, Photograph, Train	Window, Postbox, Pencil	Keyboard, Scissors, Stapler , Onions
Girl 20	Book, Car, Bridge, Snail, Laptop, Shoes, Photograph	Elephant, House, Paperclip, Monkey, Paper , Scissors	Keyboard, Scissors, Street, Onions, T-shirt, Elephant , Rhino, Socks

Table Showing the Responses from Men

	Visual List	Audio List	Audio/Visual List
Man 1	Book, Car, Train, Bridge, Shoes, Photograph	Pencil, Window, Cavern , Shoes , Camera , Paperclip, Sky	Socks, Postbox, Rhino
Man 2	Book, Car, Bridge, Curtain, Laptop, Train, Snail, Photograph	Elephant, Paperclip, Pencil, Window, House	Socks, Saxophone, Scissors, Street, Sky, Rhino, Keyboard, T-shirt
Man 3	Book, Car, Snail, Laptop, Brush, Bridge, Train	Elephant, Paperclip, Piano, House, Monkey, Scissors, Window, Carrots, Letterbox , Pencil	Keyboard, Scissors, Street, Onions, Sky, T-shirt, Rhino, Saxophone, Postbox, Socks
Man 4	Book, Car, Bridge, Snail, Laptop, Train, Photograph, Curtain	Elephant, Paperclip, Piano, House, Postbox, Pencil, Monkey	Keyboard, Scissors, Street, Onions, Postbox, Saxophone, Socks
Man 5	Car, Train, Curtain, Snail, Brush, Shoes, Picture , Laptop	Elephant, Carrots, Monkey, Pencil, Window, Piano, Paperclip, Postbox	Keyboard, Postbox, Onions, Socks, Saxophone, Rhino, Scissors, Street, Sky, T-Shirt

Table Showing the Responses from Women

	Visual List	Audio List	Audio/Visual List
Woman 1	Book, Car, Bridge, Snail, Laptop, Shoes, Curtain, Photograph	Elephant, Paperclip, Scissors, Monkey, Postbox, Carrots	Keyboard, Scissors, Postbox, Onions, Street, Socks, Rhino
Woman 2	Book, Car, Bridge, Snail, Laptop, Brush	Elephant, Carrots, Window, Scissors, Paperclip	Keyboard, Scissors, Street, Onions, Saxophone, Rhino, Postbox, Socks
Woman 3	Book, Car, Bridge, Snail, Laptop, Shoes	Elephant, Paperclip, Piano, Scissors, House, Postbox	Keyboard, Scissors, Street, Onions, T-shirt, Sky
Woman 4	Book, Car, Bridge, Snail, Shoes, Laptop, Photograph	Elephant, Paperclip, House, Postbox, Paper , Pencil	Keyboard, Scissors, Saxophone, Rhino, Post office , Socks
Woman 5	Book, Car, Bridge, Laptop, Brush, Shoes, Curtain, train, Photograph	Elephant, Paperclip, House, Window, Monkey, Video	Keyboard, Fence , Onions, Rhino, Postbox, Socks

Table Showing Number of Correct Words Recalled by Boys

Test Subject	Number of Correct Words Recalled (/10)		
	Visual List	Audio List	Audio/Visual List
Boy 1	6	5	3
Boy 2	7	6	8
Boy 3	6	6	5
Boy 4	7	4	5
Boy 5	6	4	4
Boy 6	5	4	4

Boy 7	5	5	5
Boy 8	9	8	8
Boy 9	8	9	10
Boy 10	7	5	6
Average	6.6	5.6	5.8
Range	4	5	7

Table Showing Number of Correct Words Recalled by Girls

Test Subject	Number of Correct Words Recalled (/10)		
	Visual List	Audio List	Audio/Visual List
Girl 1	7	1	7
Girl 2	7	6	4
Girl 3	8	8	7
Girl 4	8	7	5
Girl 5	7	4	5
Girl 6	7	8	8
Girl 7	7	7	9
Girl 8	7	9	6
Girl 9	5	4	6
Girl 10	5	5	3
Girl 11	8	8	9
Girl 12	5	7	2
Girl 13	6	3	4
Girl 14	5	4	6
Girl 15	5	5	4
Girl 16	7	8	8
Girl 17	6	5	6
Girl 18	6	6	7
Girl 19	4	3	3
Girl 20	7	5	7
Average	6.35	5.65	5.8
Range	4	8	7

Table Showing Number of Correct Words Recalled by Men

Test Subject	Number of Correct Words Recalled (/10)		
	Visual List	Audio List	Audio/Visual List
Man 1	6	5	3
Man 2	8	5	8
Man 3	7	9	10
Man 4	8	7	7

Man 5	7	8	10
Average	7.2	6.8	7.6
Range	2	4	7

Table Showing Number of Correct Words Recalled by Women

Test Subject	Number of Correct Words Recalled (/10)		
	Visual List	Audio List	Audio/Visual List
Woman 1	8	6	7
Woman 2	6	5	8
Woman 3	6	6	6
Woman 4	7	5	5
Woman 5	9	5	5
Average	7.2	5.4	6.2
Range	3	1	2

Table Showing how Frequently each word was remembered (Visual List)

Word	Frequency
Book	39
Car	38
Bridge	33
Snail	35
Laptop	29
Brush	14
Shoes	19
Curtain	15
Train	29
Photograph	22

Table Showing how Frequently each word was remembered (Audio List)

Word	Frequency
Elephant	39
Paperclip	33
Piano	15
House	27
Scissors	17
Monkey	23
Window	15
Carrot	16
Postbox	20
Pencil	27

Table Showing how Frequently each word was remembered (Audio/Visual List)

Word	Frequency
Keyboard	32
Scissors	25
Street	21
Onions	19
T-Shirt	19
Sky	13
Saxophone	19
Rhino	30
Postbox	21
Socks	26

Table Showing Overall Averages and Rankings for all List Categories

List Category	Overall Average (/10)	Ranking
Visual	6.625	1st
Audio	5.75	3rd
Audio/Visual	6.075	2nd

Table Showing Averages and Rankings for all List and Test Subject Categories

Test Subject Category	List Category			Overall Average (/10)	Ranking
	Visual Average (/10)	Audio Average (/10)	Audio/Visual Average (/10)		
Boys	6.6	5.6	5.8	6	3 rd
Girls	6.35	5.65	5.8	5.9	4 th
Men	7.2	6.8	7.6	7.2	1 st
Women	7.2	5.4	6.2	6.26	2 nd

Table Showing Averages for Combined Test Subject Categories (for discussion)

	List Category			Overall Average (/10)
	Visual Average (/10)	Audio Average (/10)	Audio/Visual Average (/10)	
Boys + Girls	6.433333	5.633333	5.8	6.0
Men + Women	7.2	6.1	6.9	7.6
Girls + Women	6.52	5.6	5.88	6
Boys + Men	6.8	6	6.4	6.4

Table Showing the Overall Range for each List Category

Test Subject Category	Range
Visual	5
Audio	6 (excluding outlier)
Audio/Visual	8

Table Showing the Overall Range for each Test Subject Category

Test Subject Category	Range
Boys	7
Girls	7 (excluding outlier)
Men	7
Women	4

Table Showing Likelihood of Making a Mistake for all List and Test Subject Categories

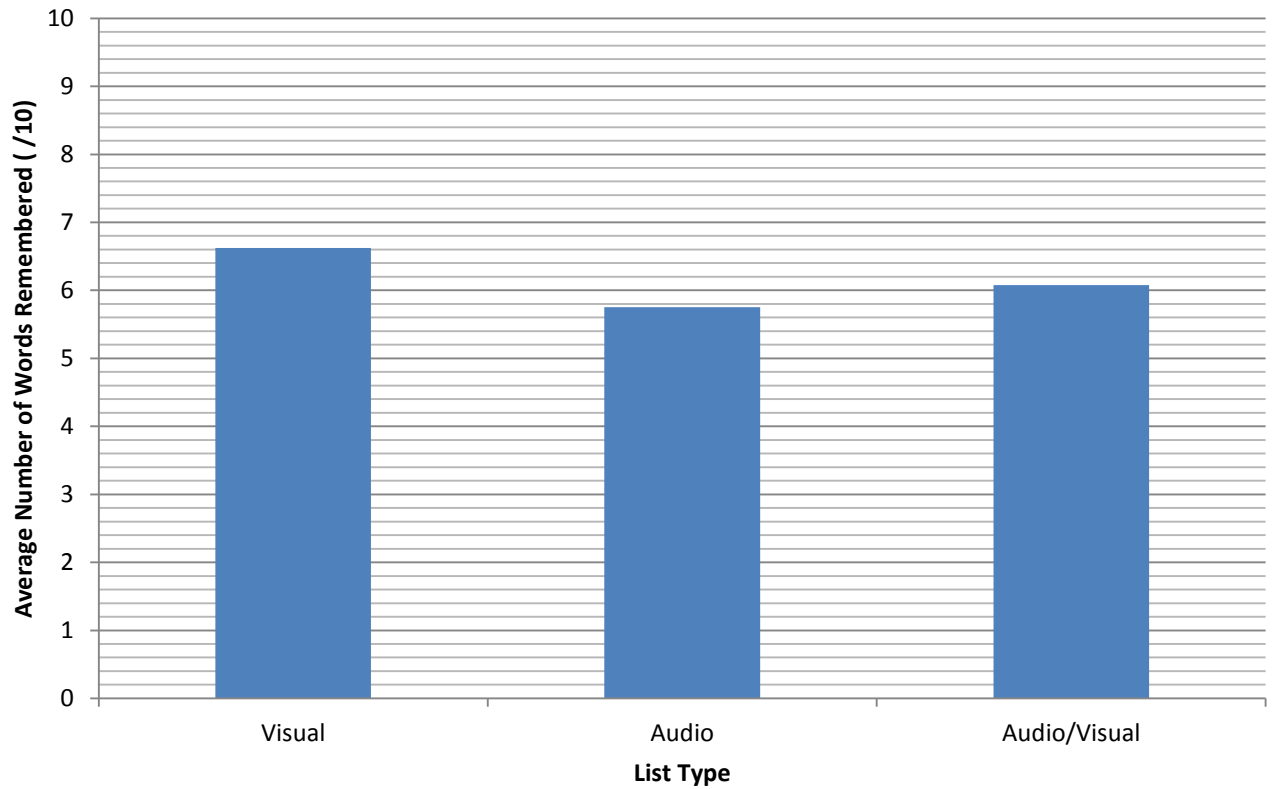
Test Subject Category	List Category		
	Visual Mistake Rate (%)	Audio Mistake Rate (%)	Audio/Visual Mistake Rate (%)
Boys	0	5.08	7.94
Girls	6.62	2.59	2.52
Men	2.70	10.53	0
Women	0	6.89	6.06

Table Showing Overall Mistake Rates for List Categories

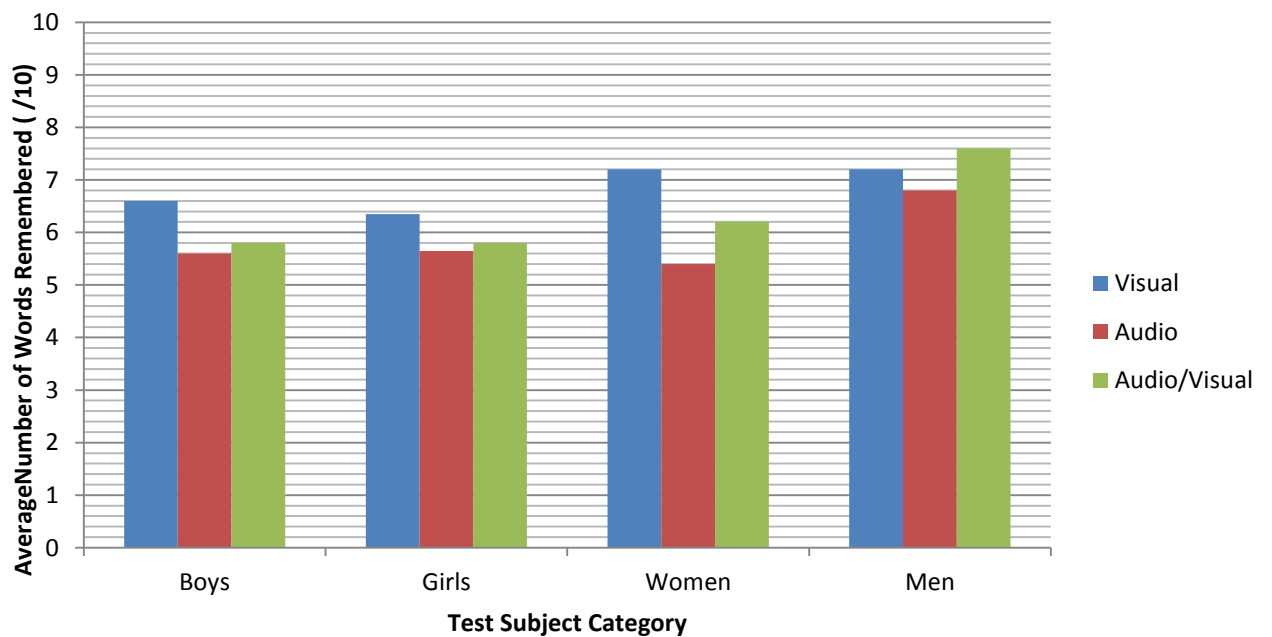
List Category	Mistake Rate (%)
Visual	3.64
Audio	4.96
Audio/Visual	3.95

Graphs

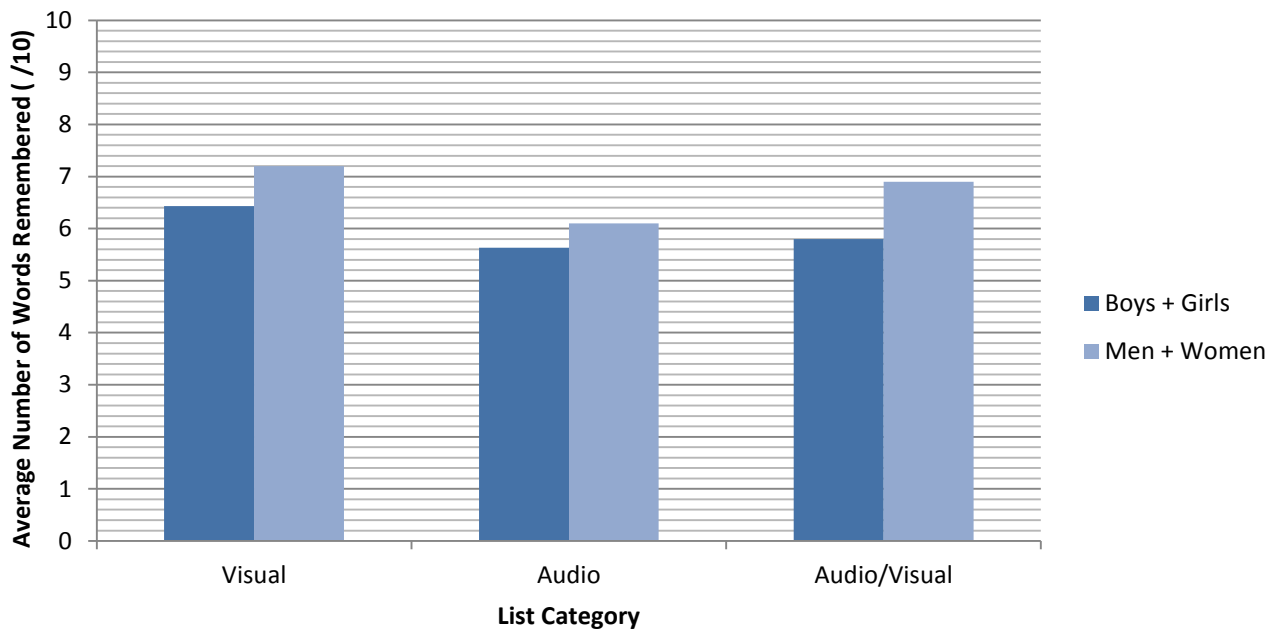
Overall Average Number of Words Remembered



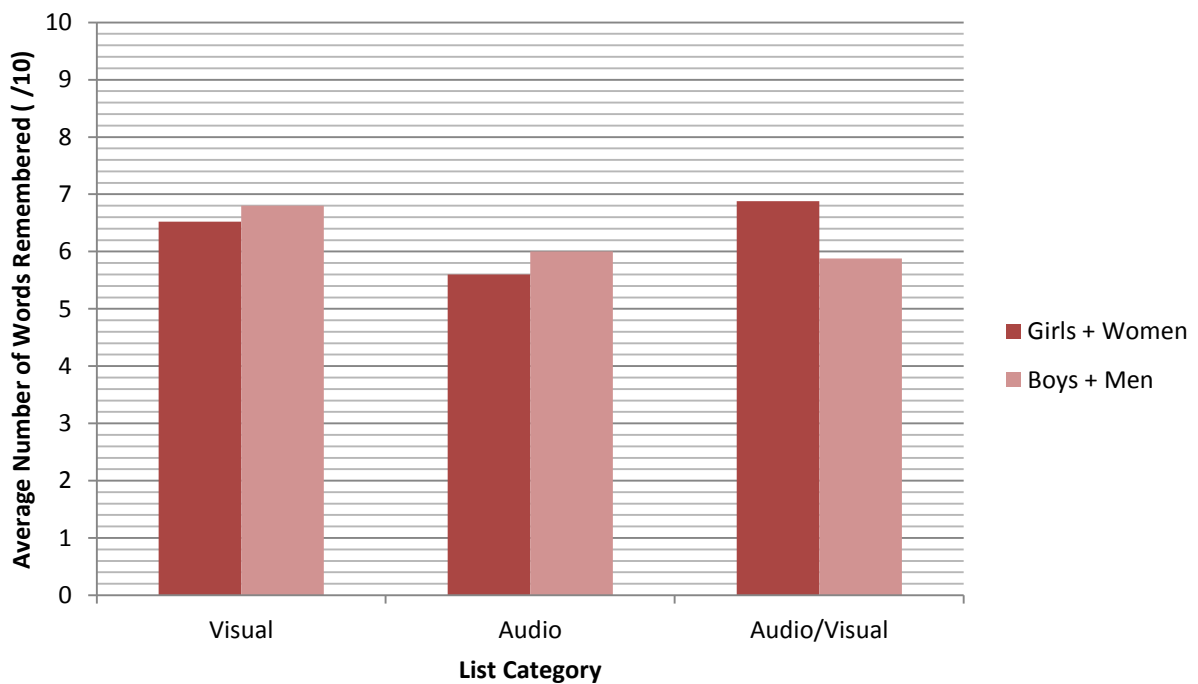
Average Number of Words Remembered For Each Test Subject Category



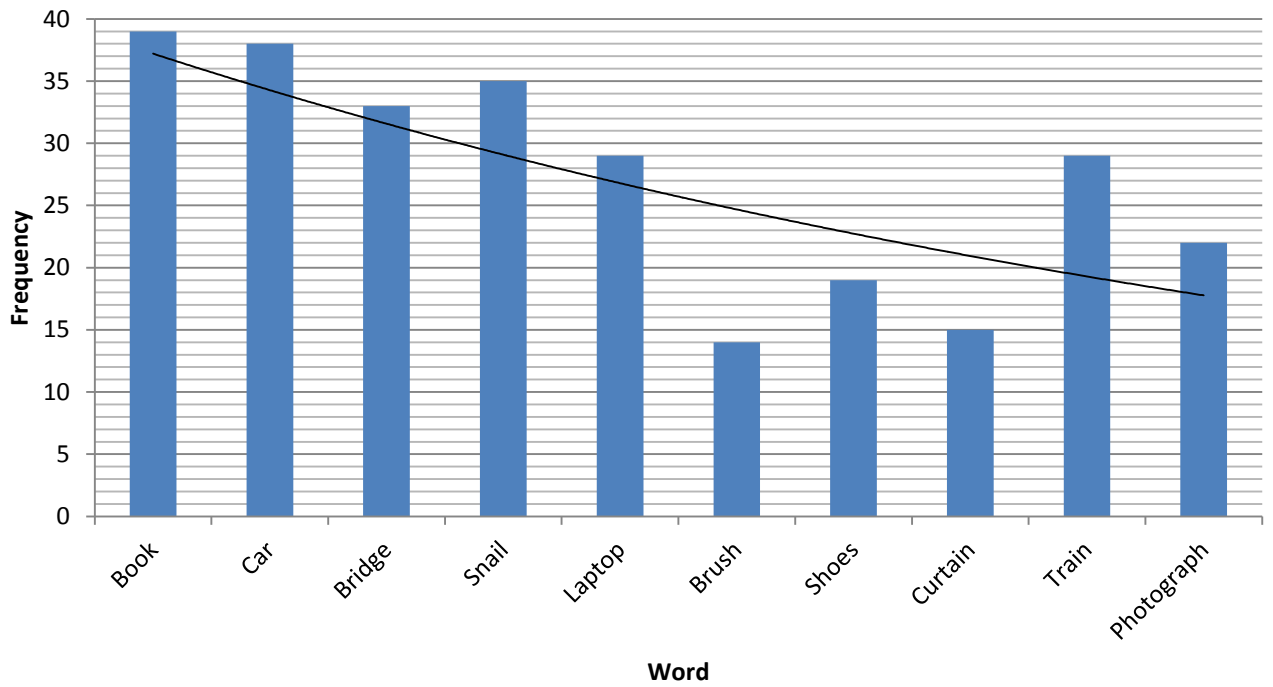
Teenagers Vs Adults



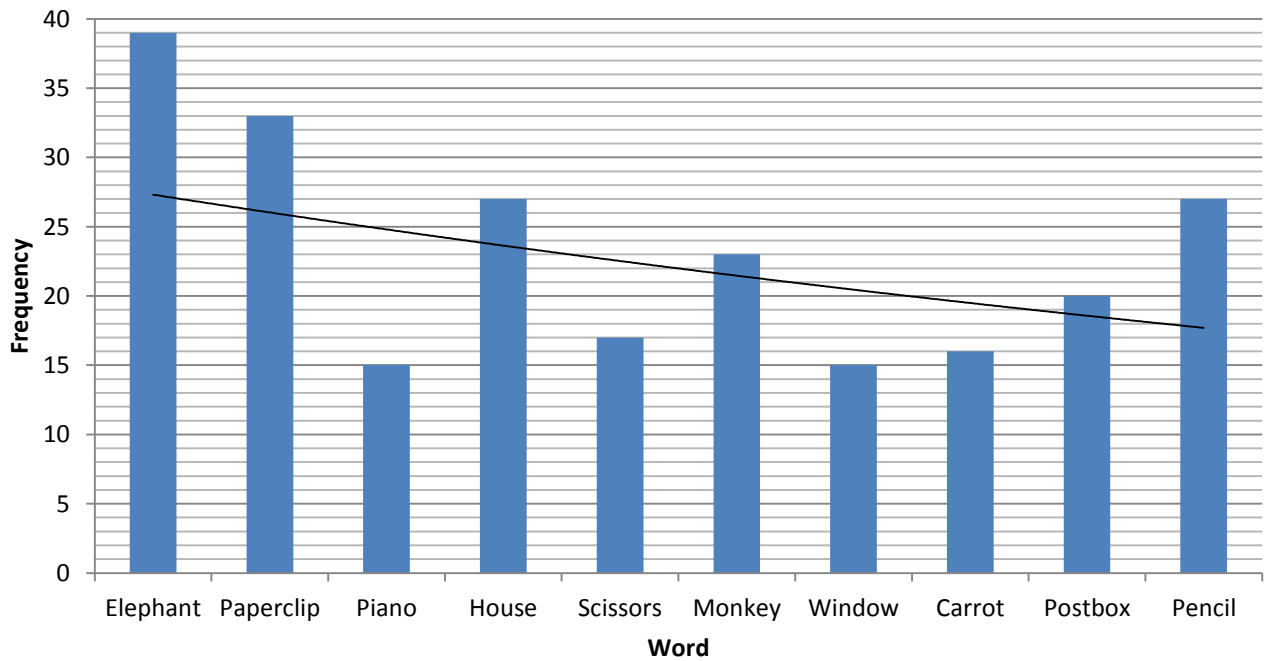
Female Vs Male

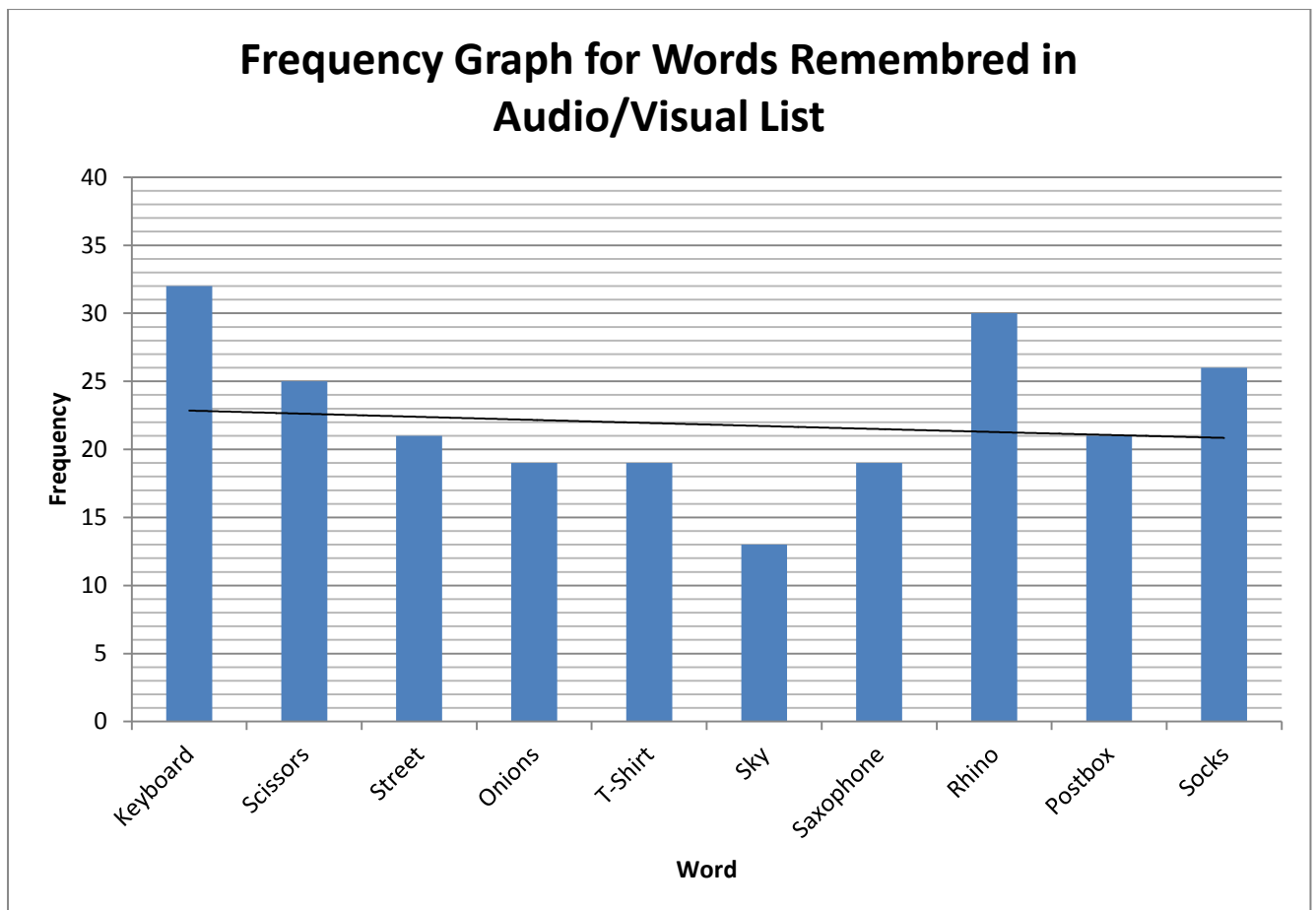


Frequency Graph for Words Remembered in Visual List



Frequency Graph for Words Remembered in Audio List





Discussion

The results in this experiment proved the hypothesis wrong because Visual information was recalled the most effectively (with an average of 6.63/10) followed by Audio/Visual (6.08/10) and then Audio (5.75/10). Visual information was also recalled the most consistently (with a range of 5) then Audio, (with a range of 6) and finally audio/visual (with a range of 8). Some test subjects responded to the test saying that having information presented in both visuals and audio was more confusing/off-putting than having the information presented in a single form. This is reflected in the high range of results from this category, as some subjects were used to processing information presented this way and others weren't.

In the experiment, Men remembered the words the most effectively overall (with an average of 7.2/10), followed by Women (6.26/10) Boys (6/10) and then Girls (5.93/10). Boys, Girls and Men all recalled the words at the same fairly low consistency, (a range of 7), but Women had a much higher consistency (a range of 4).

Girls had the lowest mistake rate (4.04%), followed by Women (4.08%), followed by Boys (4.26%) and then Men (4.42%). It can be concluded from these results that females are less susceptible to mistakes and concentrate more in the encoding process, however the mistake rates have a low margin of difference so there isn't

significant variation the genders and the mistakes they make. Males were better at recalling information presented in singular forms (Visual, Audio) but Females were more effective in remembering the Audio/Visual list. This could relate to the common belief/theory that females are 'better at multitasking' than males, and could be a topic for investigation in further detail. However, three subjects who scored 10/10 were all Male (one Boy, two Men) and all three were from the Audio/Visual list. There weren't enough Males tested to be able to make reliable conclusions about these observations, but the results suggest that some males excel in this area and some are very unskilled in registering multiple senses at once.

One main mistake in serial recalling was that people didn't concentrate enough in the encoding process. This was reported back by a large majority of participants, saying they "spaced out" or "couldn't concentrate for the full list of words". The main outlier (Girl 1, who recalled only one word from the audio list) responded to this result saying that she wasn't concentrating when the list was presented to her, meaning she had no information to recall when the time came to write down the words. Her result from this list was excluded from the calculations of averages and ranges so the final results weren't skewed.

The other main mistake was that many subjects recalled words associated or similar with the original word, but not the correct word itself. This type of error is common in serial recall and was expected as it has been proven in previous investigations (Mastin, 2010). This proves that an important part of the memory process relies on previous experiences and emotions associated with the stimuli. One example of this is Man 3 who recalled "letterbox" instead of postbox (to see more, look at the **bolded** words in the results tables).

Another error was when some of the subjects recalled a word in the current list that was stated in a previous list. The results were expected because this was investigated in the background research. Like what was stated in the research, nearly all of the times this error occurred, the word was in the same/similar position as it was in its original list. When a word was missed, it was likely to be recalled straight after the word that was recalled too early.

Other reported reasons for mistakes were misheard words when the Audio list was presented. Some found that the longer words were harder to recall and took longer to write down. The Visual list had more one-syllable words which were reported to be easier to remember.

The Visual list had the lowest mistake rate (3.64%), followed by Audio/Visual (3.95%) and then Audio (4.96%). This is expected as it reflects the overall result of the experiment, as Visual information was remembered the most effectively, followed by Audio/Visual and then Audio.

There were many trends, patterns and relationships that occurred in the results. One noticeable trend was that the further down the words were in the list, the less

frequently test subjects recalled them. This may be because the average human attention span in 2013 was 8 seconds (Statistic Brain, 2014). Each word was shown for four seconds, so even after the second word, the candidate's attention span wouldn't have been at its full potential. This also explains why the results in the Audio/Visual are much less consistent and also don't show this visible relationship, they tended to be remembered more randomly because it was the final list and the test subjects may have been less concentrated. It was also reported that the subjects that recalled the words in order, using a mnemonic link (e.g. a story) tended to get a higher score. However, in the feedback, many said that it was difficult to use this technique with the Audio/Visual list because the presence of two different forms of information was confusing. (Hence the large range of results and more people failing to recall the words in order). This may have been because the word was read out more slowly than it takes to read something silently or because the voice pronounced the words differently to the test subject.

If the same word was in two lists and the test subject recalled it in one list, it was very likely to be recalled in the other list as well. The two words "postbox" and "scissors" were purposely placed in two different lists and it was a common occurrence for the test subject to remember the same word in both lists. (e.g. see *Boy 8*)

After this experiment was carried out, it was noticed that the older population performed better than the younger population. This wasn't expected because as people age, there is more cell-loss in the area of the brain which produces a neurotransmitter called acetylcholine which is essential in the memory process (Mastin, 2010). Adults performed better than teenagers in every list. For the Visual list, the average for teenagers was 6.43/10 and the average for Adults was 7.2/10. For Audio, teenagers scored 5.63/10 and Adults scored 6.1/10. For Audio/Visual teenagers scored 5.8/0 and Adults scored 6.9/10. This may be because their brains have had more practice, their synapses are stronger and they have more experiences/previous memories to associate the stimuli with. The five men and five women were all university educated, therefore their cognitive function, brain performance and memory is more effective when compared to non-educated adults (Skirbekk, 2014). These observations can raise many questions for future experiments – to test whether basic memory is different between educated and non-educated people, to determine the age at which the memory function deteriorates, or simply just to compare the ages and their memory processes at more detail.

These results of this investigation were similar to the results of previous experiments conducted by institutes such as the National Academy of Sciences USA or by journals such as Applied Cognitive Psychology (for full, detailed list, see *Research*). All of these similar experiments concluded that visual information was recalled more effectively than audio information, which is what can be concluded from these results (averages discussed on pg. 26). This also means that the results are accurate.

The data gathered is reliable for the purpose of proving the hypothesis – the experiment was completed 40 times and aside from a few outliers, the results agreed with each other. However, because there was not access to enough adults, conclusions couldn't be drawn about specific ages or genders as the test was not carried out enough times in the individual categories. The proportions of the test subject categories were also not representative of the national population.

The results of this experiment are valid because the method was valid and the data was accurate and reliable. The method was valid because all variables were controlled as much as possible (see *Why the method is valid*). They could have been controlled even more if the experiment was set up rather than sent out for people to conduct individually, but this was unrealistic and hard to achieve. There was only one independent variable (the way the information was presented) and the dependent variable didn't need to be measured with equipment which eliminates human error when taking measurements – meaning all results are completely accurate without any margin of error. They are also accurate because the results reflected similar experiments carried out by professionals/universities etc. (see pg. 28 and in *Research*).

This experiment and method could be improved in multiple ways. It would be easier to manage the controlled variables if there was just one laptop set up and all the subjects would take the memory recall test in the same room on the same laptop. This means that there would also be no time to wait for results to be sent in, leaving more time to evaluate results. The results would be more representative of the population if the sample was a stratified sample rather than a quota sample. If more candidates were selected, conclusions could be drawn on more specific categories. The data could also be more representative of the overall population if the people were selected from different schools/types of education as this may affect brain capabilities and habits. The experiment could be even more valid if the hours of sleep and time of day were made controlled variables, as the amount of sleep affects brain function (National Institute of Neurological Disorders and Stroke, 2013). Gathering the data was difficult and inconvenient because the test subjects didn't take the test straight away and there was period of time spent waiting for results instead of continuing on with the analysis of results.

Conclusion

Information is recalled the most effectively when it is presented visually, followed by when it is presented with visuals and audio, and then audio.

Self-Evaluation

I am happy with my effectiveness in completing the task. I made a schedule and stuck to it fairly well, except when it became further to the end of the task. This is because I didn't leave enough time for the test subjects to respond, and many took over a week to complete the test. I couldn't continue with analysing the results until all 40 people had completed the experiment. It was hard to replace the people who took a long time as I had limited access to Boys, Women and Men. Next time I will consider these obstacles when planning and scheduling future experiments. However, after the slow-down, I understood and interpreted the results fairly easily, which made it easier to catch up the time I had missed. It was also lucky that I was prepared and sent out the video early-on. I really enjoyed this SRP because I chose a topic I was genuinely interested in, which made me excited and motivated to investigate further into how the brain functions and patterns of memory. It also was useful to help me consider future jobs in Psychology as I was doing real, first-hand investigations on the topic and not just thinking about what this job would be like. Some other ideas for future experiments/investigations are; testing whether colour affects memory, testing whether pictures or text is remembered better and investigating what would happen to memory recall when the audio doesn't match the visuals

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