

## Research Project Folio: Kezia Robinson

### Topic selection:

When I started this research process I was interested in doing something with a neurological aspect. However, I also wanted my question to have an everyday application, so I could use the findings in my own life. I was immediately drawn to the neurological benefits of physical activity as it is a relevant and ever-expanding topic.

#### Topic PMI:

P- This is a great question to research and look into because it is an idea that is continuously being researched and new findings are continuously being sought out to gain a bigger and clearer picture on the interaction between the two.

M- This topic could potentially not have a clear-cut answer because there are so many factors which exercise can help with. Therefore, I would need to be more specific in how exercise affects the brain.

I- I am thoroughly interested in this topic because through completing research I can benefit personally and collectively with others. This will be useful in later life when studying further and trying to maintain an active lifestyle.

#### Question refinement:

##### Question 1: How does exercise affect the brain? (31/1/19)

P- This is a very modern topic which is applicable to everyone making it important to consider. By choosing two interlinking factors which exercise could potentially improve, it shows the broadness of the topic whilst remaining quite specific.

M- At the moment, this question is far too broad because from preliminary research it is evident that exercise have many different effects on the brain and body, therefore I will need to be more specific in what areas exercise affects the brain.

I- This is a very interesting topic as it the benefits gained and assist everyone in the world. Exercise is crucial to living a healthy life, so with potential academic benefits it could be even more vital than previously thought. Also, with currently being in year 12, if something I enjoy can help my studies, then it can help others too.

##### Question 2: How does exercise improve attention span and memory? (1/2/19)

This question needs a slight tweak to make it sound more focussed and directed. By saying "How" it leaves the question as comprehensive without a focus on what type of answer it will have. Also, I think the term physical activity is more accurate as I want to focus on raising the heart rate, not exercise in general areas.

##### Question 3: How does aerobic exercise improve memory and concentration? (15/2/19)

P- After conducting some preliminary research, it was evident that there are two main types of exercise; aerobic and anaerobic. As I want to focus on cardiovascular exercise such as recreational sports it was clear that I needed to focus my question on this certain type of exercise. Concentration also helps refer to the level of focus, not just the amount of time. The factors researched, meant that it wasn't a question of whether exercise helps or not, but how it does help.

M- I think it would be quite hard to conduct my own primary research because it is quite a niche field, as well as hard to get reliable data from a case study that I conduct.

I- This will be interesting as it can assist in my study during year 12 because I can find out how much memory and concentration are affected and implement the findings in my own life.

##### Question 4: How does aerobic exercise improve memory? (11/06/19)

After completing the development and analysis of my research I realised that there was far more to the effect of exercise on memory than I initially thought. Therefore, I decided to cut out the effect of exercise on concentration because there was more detail and ground-breaking effects on memory than on concentration.

#### Question breakdown:

- Neurological changes that occur with exercise
- How changes improve memory (application)

### Planning of research processes:

**What source:** Website

**Where to find it:** Online

**Type of source:** Secondary (generally)

**Who can help:** -

**When to use:** I would use this source to start off my research. This is because they are easier to comprehend and introduce me to specialised vocabulary before analysing sources that use complicated vocabulary. This would help me to find more specific areas and further in-depth sources.

**How is this source useful?** This source is useful because it can cover a lot of information on the topic. The validity will be good as I can search very specific areas.

**Limits of the source:** Limits of these sources will be that not all of them will be reliable and credible. So, I need to make sure that the author is an expert in the field and they have reliable information.

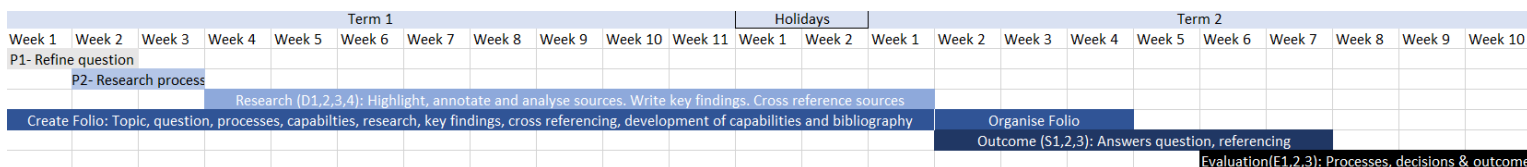
**What source:** Journal articles  
**Where to find it:** State library and online  
**Type of source:** Primary  
**Who can help:** Researchers in neurological benefits of physical activity and neurologists  
**When to use:** I would use these sources throughout the research process, because they would go into more depth than any other source. This means I need to know what they are talking about first and select only useful information.  
**How is this source useful?** They give reliable data and information. They also contain advanced knowledge, which will provide greater depth.  
**Limits of the source:** These sources wouldn't be very good for initial research and initial understanding due to their depth and complexity.

**What source:** Books  
**Where to find it:** Libraries and state library for e-books  
**Type of source:** Primary and secondary  
**Who can help:** Librarians to help me credible books  
**When to use:** I would use these types of sources to receive more reliable information on neurological information. This is because detailed informative books will be written by experts of that field.  
**How is this source useful?** This source will help because they will provide expert and information full of knowledge which will help once I have my topic more refined.  
**Limits of the source:** These sources are limited because they wouldn't point me towards other reliable sources, so it'll be best to use them after preliminary research.

**What source:** Investigations  
**Where to find it:** I will conduct them myself  
**Type of source:** Primary  
**Who can help:** My Biology teacher helping with my investigation design would help immensely due to the fact that they are providing raw data for me to use and draw conclusions from.  
**When to use:** An investigation will only be valuable if enough information to prepare for it is gained to ensure it aids my research. I plan to conduct it after my preliminary research, however, if it is unsuitable because the data is too unreliable, or the boundaries are unrealistic then I will have to consider other options like analysing investigations others have conducted.  
**How is this source useful?** Because it provides personally collected data which can be targeted to observe patterns and answer specific questions.  
**Limits of the source:** It may be unreliable as I am not an expert and may not have full control of independent variables.

**What source:** Emailed interviews  
**Where to find it:** Create my own questions  
**Type of source:** Primary  
**Who can help:** Researchers of how memory works and researchers of physical activity's relation to concentration  
**When to use:** This source will be used to confirm my questions after some initial research. This is because any loose ends which I need to tie up or any necessary answers which I need can be answered directly. However, I will need to get onto it fairly promptly to allow time for slow replies.  
**How is this source useful?** These will be so useful to have as they provide inside and personal information, which I know can be trusted and highly relevant as they are experts.  
**Limits of the source:** The limitations of these sources would be that it might be very slow for me to get replies and they might only reply the exact information I requested for, meaning I'll have to ask specific questions on areas I'm unclear or need information for.

Gantt chart:



This Gantt chart will help to make sure that I am on track, so that I complete everything. By having set blocks and performance standards highlighted that I need to include, this will help focus my attention on the important things and not get distracted, thus losing crucial time.

Planning of capability development:

During this research process the most relevant capability to me would be the critical and creative thinking capability. This capability has a lot of room for development as critical, logical, ethical and reflective thinking is a wide but in-depth process. By reflecting on synthesised reliable and valid information is crucial to getting the key information from vast amounts of scientific material. Also, this is a learning process as it is a modern scientific topic, therefore, the ability to apply newly comprehended knowledge is important by writing down any key findings from each source. Thus, the organisation of sources and key findings is key because fully evaluated and organised information, through cross referencing, will make answers and referencing in the outcome much easier.

Plan with sources:

The approach I will take for analysing my sources will be to become familiar with the source by reading it through. I will then go through a second time specifically highlighting key findings, quantitative and qualitative data, important and reliable quotes and any other useful information. Annotating the source will also be important to help me understand the source in a greater depth and to ensure clearer evaluation. Furthermore, I

will evaluate the sources reliability, credibility and validity. All this will be put into my folio, as well as key findings, source details, leads and redirections and my conclusion on the source with cross references between sources.

### Development and analysis of research:

Challenges	Opportunities
It'll be hard to get primary sources in such a short amount of time from people who are knowledgeable in the field because it is such a niche topic.	Making sure that my research cross references and agrees with other sources.
It may be hard to understand in-depth scientific sources on the connection between aerobic exercise and how it changes the brain but the benefits will provide my research with new depth.	This is an ever-expanding topic which has new and relevant information, so I should get a lot of reliable sources which I can trust and use.

**Physical activity has comprehensive health benefits across the lifespan. It promotes healthy growth and development in children and young people; helps prevent unhealthy mid-life weight gain, and is important for healthy ageing, improving and maintaining quality of life and independence in older adults.** (Source: British Journal of Sports Medicine - BMJ) - Link of this Article

The recent press release regarding your work reported that "regular" participation in sports and/or exercise has clear benefits for physical and mental health. Please could you define "regular", i.e. how much exercise should we be doing to gain these benefits?

This is easy to answer in two ways. First, the guidelines are that each of us should accumulate 150 minutes of moderate to vigorous physical activity per week. That's 22 minutes a day of walking! That advice is for 'public health' - it will make a population healthier compared with being sedentary.

The second answer is that as an individual, it makes really good sense to accumulate 60 minutes of moderate to vigorous physical activity daily. This is still just walking - and it can be done in 10-15 minute bouts! So it still leaves 23 hours a day for sitting, lying and sleeping!

Why 60 minutes? Because there is a 'dose-response' curve - and so by being 'selfish' and taking twice the public health dose of physical activity, I reduce my risk of death, dementia, key cancers, coronary artery disease, a further 20%. It's not as good 'value for money' as the first 30 minutes but I am going to sneak that extra dose while no-one is looking!

After 60 minutes the benefits largely level off to a point. Superior fitness is associated with superior health but do at least 30 minutes daily. If you are scared of cancer, dementia, a low quality of life and dependency in later life - accumulate 60 minutes and do it now!

**Reliability:1** This source has a good level of reliability because the facts and thoughts are all coming from people who are highly qualified to talk about the topic. However, this source may be seen as objective, as the interview was interviewed is well known for being a strong advocate for physical activity and public health. Also, it was recorded several years ago and therefore, due to my subject being influenced so much by modern science and modern knowledge, new information may have been uncovered during that time.

**Key findings:1** The major key finding from this source was that the brain has a dose-responsive curve reply to exercise, so the more that is undertaken the better the response is. This also backs up the finding that the biggest benefits come in the first 30 minutes of exercise, with a slower progression of benefits after this. These are interesting findings because this shows that even a little bit of exercise can have more dramatic effects than a long period of exercise.

**Validity:1** This source has some interesting and thought-provoking information, however, it doesn't answer the exact question that I am focussing my research on. So, it hasn't provided many key findings, although it is useful in that it has provided many leads to other sources.

**Conclusion on source:1** After analysing and evaluating the source, my conclusion on this source is that this is very useful for background knowledge and a foundation for my research, however, nothing in this source will be used to lead an argument as it would be invalid.

**Source details:1** Khan.K, 2012, Exercise and health: An interview with professor Karim Khan, Interviewed by April Cashin-Garbutt for News medical life science, 12<sup>th</sup> September 2012

**Leads:1** This source has greatly influenced the direction of my research, particularly in being part of my preliminary research. This source has been introduced just how vital exercise is to preventing diseases, as well as the professional help that can be received by those who are deemed unfit. This isn't really where I want to concentrate my research, therefore it will focus my attention on the physiological changes that happen in the brain, due to exercising.

**How Exercise Changes the Brain**

Neuroscientists have varying theories about how exercise prompts the brain to re-model itself, each involving re-mediated biochemical processes. One possibility is that exercise provides the environment brain cells need to grow and expand and so we find the challenge requiring stronger and more robust neurons that circulate in the blood and are ready to be recruited to the brain.

Exercise also prompts the brain to produce more of the growth factors that are needed to support the brain's health and function. These factors are produced in the brain and elsewhere in the body, pumped out in greater quantities during and after exercise.

There's a bona fide neurochemical problem (BNP) in the brain, which has been found to contribute to the control of stem cell division. Your brain is packed with adult stem cells which, given the right prompts, divide and differentiate into either additional stem cells or young neurons. As we age, those stem cells tend to become less responsive. They don't divide as readily and are using up a kind of cellular 'dose' - BNP acts as a sleep aid. The more active BNP an individual has, the more responsive your brain's stem cells become and the less neurodegeneration you brain undergoes. Your brain grows slower, less sensitive, and therefore what your neurological and physiological state. Not exercise counteracts some of the waning effects of BNP.

Exercise also dramatically alters how you feel. Even a small amount of activity can make an enormous difference in the functioning of the brain.

Vigorous exercise isn't necessary to protect your mind. Just walking around the block makes a difference. The longest study of overall health, Harvard's Nurses Health II, showed that people who walked for 30 minutes a day showed a more healthful approach on the job, less taking the stairs throughout the day rather than the lift.

**Reliability:2** This source is written by someone with no credentials but rather evaluates collaborative strategies from credible authors to provide information. The information is also current and published professionally, showing reliability. It is written with the purpose to encourage workforces to create a better environment and boost productivity. Therefore, it has an average reliability.

**Validity:2** The usefulness of this source is extremely high, with much valid and key information presented. The key information related directly to my topic, especially in the physiological changes to the brain and the benefits from that such as improving higher mental processes ability.

**Conclusion on source:2** This source provides a lot of useful and valid information. However due to uncertainty in its reliability, I will have to cross reference and back up the ideas presented before using them in my outcome. This source also helped me develop my skim-reading ability to ascertain whether the source is worth reading properly based on reliability factors.



**Key findings:2** The key ideas from this source, include the finding that brain-derived neurotrophic factors (BDNF) are a vital element produced during exercise. This factor helps neurons develop and thrive themselves, as well as consolidating short-term memories into long-term ones. This is evidence that the more exercise that is undertaken, the more memories will be consolidated. Another key finding was that exercise counteracts the negative effects of the bone morphogenetic protein (BMP) on stem cells. Also, Insulin-like growth factors are produced in greater amounts in response to exercise. Exercise helps IGF1 to pass through the blood-brain barrier sparking neurogenesis and other changes in the brain tissue.

**Leads:2** This source has provided many leads to other sources and has helped focus my attention on what may be major findings in my research. I need to focus on the impact Brain-derived neurotrophic factors and Insulin-like growth factors have on the brain physiologically and how these changes improve memory. Another lead which I want to explore is, the scope of benefits in the first 30 minutes of exercise. Because the application from this is far simpler than assigning a specific length, intensity and exercise which everyone should be doing.

**Development of capabilities:2** Critical and creative thinking capability was developed because I had to learn and apply new knowledge and skills. Brain derived neurotrophic factors and Insulin-like growth factor 1, were new concepts that came up in this source and I had to complete some side research so that I could apply the knowledge into my findings. This means that my knowledge now goes into greater detail showing a better understanding of the topic.

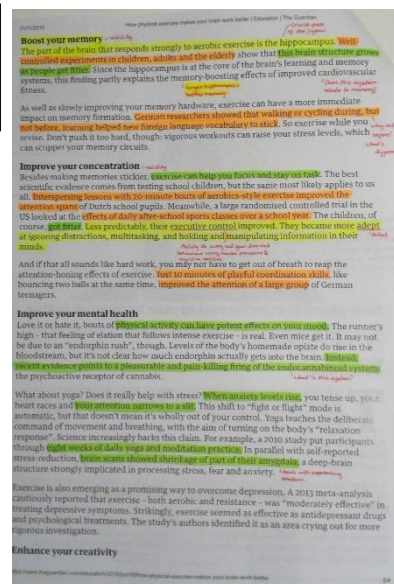
**Source details:3** Martynoga.B, 2016, How physical exercise makes your brain work better, <https://www.theguardian.com/education/2016/jun/18/how-physical-exercise-makes-your-brain-work-better>, Accessed 21<sup>st</sup> November 2018

**Reliability:3** This source has a good level of reliability because the author is a neuroscientist and science writer which matches up seamlessly with the topic in question. Although there aren't any references apparent for any of the main ideas, I don't believe this source has a bias or is unreliable because the information put together is supported by several separate studies. Furthermore, The Guardian is a reputable newspaper, therefore the information presented would be considered reliable.

**Validity:3** This source has two sections in particular which relates directly to my question. One is the improvement in memory by the growth of the hippocampus. The other is concentration, which is improved by higher executive control ability. The rest of the source has some useful information which can be linked in, my only answers my question indirectly.

**Leads:3** This source hasn't really lead me into a new area but rather given me direction within my question. The volume increase of the hippocampus is an area which needs to be explored in much greater detail as it seems to be at the foundation of the improvement in memory from exercise. Then, with concentration using specific mental processes and cognitive abilities all help to maintain focus. Therefore, the question is, which cognitive abilities are most prevalent and exactly how do they improve concentration.

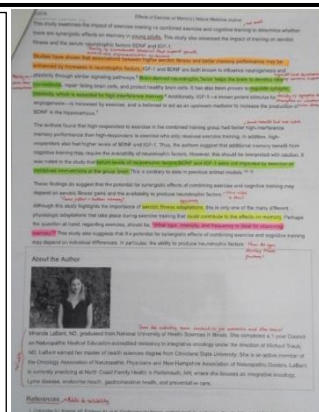
**Key findings:3** There were two main ideas that came from this source relating to memory and concentration respectively. The first is that the hippocampus is the area of the brain which responds most strongly to aerobic exercise. It also is the part of the brain which is at the core of the brain's learning and memory systems, therefore the larger the hippocampus is, the better your memory will be. The other key finding was that exercise leads to becoming more adept at executive control functions such as, ignoring distractions, multitasking and holding and manipulating information in their minds.



**Conclusion on source:3** This source is reliable and valid, so it will definitely serve as a foundation to my research as there are many avenues to explore from analysing just how memory and concentration is improved with aerobic exercise.

**Validity:4** The validity of this source is extremely high as it provides good quantitative and qualitative data about the relation of exercise on memory performance. However, some of the information refers to exercise in conjunction with cognitive training, so this data won't be applied to my research and my outcome.

**Reliability:4** This source has a below average level of reliability because, even though they are a physician, they don't specialise in exercise and the brain. Instead, she is part of the Oncology Association of Naturopathic Physicians which means that she wouldn't have much to do with studying how exercise changes the brain. However, little information presented is personal, but rather a compilation conducted by other credible professionals. This source has also been published by a well-known, trusted medical journal proving some reliability.



**Source details:4** LaBant. M, 2018, Effects of exercise on memory, <https://www.naturalmedicinejournal.com/journal/2018-04/effects-exercise-memory> , Accessed 23<sup>rd</sup> November 2018

**Key findings:4** A key finding from this source was that those who exercise have a better high-interference memory, when different memories are disrupting each other. This is translated into tasks such as, delayed free recall, relational memory and spatial learning. However, this study also connected neurotrophic factors to improved memory by stating that increases in BDNF's and IGF-1 enhance the memory performance rather than creating the improved memory.

**Leads:4** This source has altered my direction by now focussing more strongly on the neurotrophic factors BDNF and IGF-1. The focus here is, are they important and are they critical to improved memory or do they just enhance memory function? This will be difficult because this will mean going into a lot of detail about the topic, but, it will help open some doors about the physiological process that occurs when exercise is undertaken that ends up with memory being improved.

**Development of capabilities:4** Critical and creative thinking capability developed by organising, using and evaluating the information in the source to determine whether it is valid and reliable. This shows development because without being critical and logical about whether to trust the source, wrong information may be presented.

Suzuki,W. (2018), The brain-changing benefits of exercise, [https://www.ted.com/talks/wendy\\_suzuki\\_the\\_brain\\_changing\\_benefits\\_of\\_exercise](https://www.ted.com/talks/wendy_suzuki_the_brain_changing_benefits_of_exercise), Accessed 15<sup>th</sup> November 2018

- Noes on video:
- Prefrontal cortex:
  - Critical for focus and attention
  - Temporal lobe:
  - Contains the hippocampus
- A memory is formed by neurons having a brief moment of electrical activity between each other**
- Primary source area:
- She found that after she went to the gym, she was able to focus and maintain her attention on a mundane task longer than she had before.
  - Her long-term memory also seemed to improve to her, she could remember a lot more of what she was studying in her lab.
  - Literature all pointed out the exercise provides: better mood, better energy, better memory, better attention
- How exercise transforms the brain immediately:
- It has an immediate effect because exercise immediately increases levels of neurotransmitters like dopamine, serotonin and noradrenaline
  - The increase in these chemicals improves mood.
  - Exercise can increase the ability to shift and focus your attention and the improvement will last for up to two hours.
  - It also improves reaction times
- The long-term effects of exercise:
- An increase in cardiorespiratory function enables long-term affects to happen
  - **Exercise actually changes the brain's anatomy, physiology and function." Wendy Suzuki**
  - **Exercise enables the production of new brain cells in the hippocampus, which in turn leads to an increase in volume, which in turn improves long-term memory.**
  - Exercise improves attention dependent on your prefrontal cortex.
  - Good mood neurotransmitters increase and sustain for long-term improvements.
- The protective effects:
- Exercise gives the brain protective effects.
  - The Hippocampus and prefrontal cortex are two areas most susceptible to neurodegenerative diseases and exercise gives a form of protection to this.
- Length:
- 3 to 4 times a week of 30 minute sessions

**Source details:5** TEDwomen, 2017, The brain-changing benefits of exercise, Available at: [https://www.ted.com/talks/wendy\\_suzuki\\_the\\_brain\\_changing\\_benefits\\_of\\_exercise](https://www.ted.com/talks/wendy_suzuki_the_brain_changing_benefits_of_exercise), Accessed 15<sup>th</sup> November 2018

**Reliability:5** This source and the information contained in it are highly reliable because the author of the source is a professor of neuroscience and psychology at New York University. Also, the source is primary because she personally conducted the studies, meaning that the data can be trusted. The information is extremely current published on a credible website, all evidencing reliable material

**Validity:5** This source is greatly valid to my research question because it discusses how the brain changes in anatomy, physiology and function in response to exercise and this includes memory and concentration. However, this source particularly focuses on memory and how changes in the brain's hippocampus structure and improve long-term memory.

**Key findings:5** The main key findings from this source was the primary information which the neuroscientist gathered from observing herself in response to exercise. After a session in the gym, she felt more focussed and able to maintain her attention on a mundane task longer than she had previously. Furthermore, her long-term memory improved because she could remember information better. Also, from this source I noted that the increase in volume of the hippocampus is due to exercise enabling the production of new brain cells in the hippocampus, increasing the volume and improving long-term memory.

**Leads:5** Leads are abundant from this source because it gives a brief overview of everything that exercise does to the brain, meaning that there are many paths to explore from the information gathered. One of these is the individual factors that lead to a change in the brain's anatomy, physiology and function in a beneficial way.

**Conclusion on source:5** This source is a tremendously useful source, with trusted, reliable information and a great overview of changes that occur during and after exercise. This material will be used as foundation knowledge as I got into more detail about the changes

**Development of capabilities:5** The literacy capability was developed because I had to improve my note-taking skills whilst watching a video. This also developed the critical and creating thinking capability because I had to understand, evaluate and synthesise the information before taking notes.

**Reliability:6** This source is reliable because even though the author is knowledgeable but not an expert in neurology, this source is more of a report on a primary study conducted by an expert in neurology. This source was also written recently, meaning it contains modern knowledge on the topic. However, there aren't any references to other sources including the study reported. Thus, this information needs to be confirmed by other sources first.

**Validity:6** This source isn't that valid, it contains good information on findings between exercise and the ability to solve problem process information and complete the prescribed amount of activity. However, it doesn't talk specifically about the impact of exercise on memory and concentration. So, this will be used for a foundation and other leads, rather than an answer.



**Source details:**6 Park. A, 2018, Here's how much exercise you need to keep your brain healthy, <http://time.com/5294493/exercise-healthy-brain-aging/>, Accessed 21<sup>st</sup> November

**Leads:**6 There are several ways that exercise indirectly affects memory and concentration that are outlined in this source. The impacts may be subtle, but they are worth researching to understand the context behind improving memory and concentration. These effects include, preserving the brain's nerve network, boost in neuron function, promotion of growth factors and exercise promotes higher order thinking.

**Conclusion on source:**6 This source has some interesting information and provides some interesting leads. However, on the whole it isn't that ground-breaking and so will be mainly used to cross-reference other sources information to prove that the information is true.

**Key findings:**6 From this source, the main idea was that improvements in cognitive function correlated with the overall time spent exercising, it wasn't associated with frequency, intensity or length spent exercising. This was interesting as it can be concluded from this that to gain more benefits you need to exercise more, although it doesn't matter what you do specifically. Also, this source commented on how exercise preserves the brain's nerve network, boosts neuron function, promotes growth factors and promotes higher order thinking. All these factors are associated with improving memory, showing that exercise does a lot for the brain.

**Reliability:**7 This source is reliable, because it is written and published by several credible authors, who personally conducted the experiments. As well as being an academic journal article with no signs of bias. The author has also referenced all ideas with credible and valid sources. However, the main author M. Pontifex is an associate professor in the department of Kinesiology with research conducted in the area of developmental neurocognitive in relation to kinesiology, as this is an alternative method caution needs to be taken.

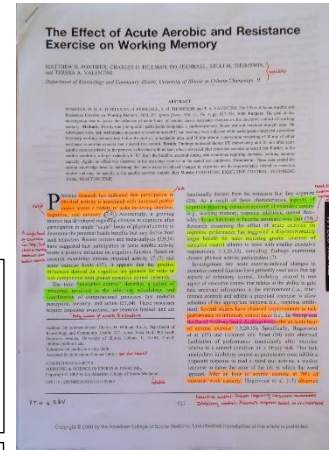
**Validity:**7 This source is highly valid because it discusses the relation of aerobic exercise with cognitive function, encompasses memory and concentration. In particular, the major effect of exercise on executive control and working memory is discussed. Therefore, this source is highly valid for my research with its answers and ideas answering my overall question.

**Key findings:**7 The key findings from this source include, exercise having a larger benefit for tasks requiring greater amounts of executive control and inhibitory control. It also revealed, exercise increase neuronal proliferation (the differentiation of neurons) including neurotrophic factors such as BDNF and serotonin leading to neurogenesis in the hippocampus.

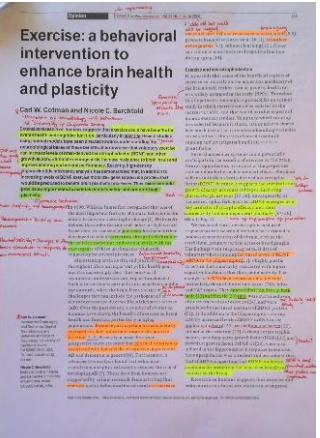
**Leads:**7 This source has leads in the executive and inhibitory control areas which I know little about, therefore this will cause me to look into what the areas are, what part they have to play in exercise improving memory and how they fit into the process of improving memory?

**Conclusion on source:**7 Overall, this source is excellent and the key findings it have are useful towards answering my question, therefore, this source will be a great help when going into detail in my outcome.

**Development of capabilities:**7 The critical and creative thinking capability was developed because some of the information was had complex scientific vocabulary. So, I researched, identified and explored these ideas and concepts so that I could understand the article and glean the key findings from it.



**Source details:**7 Pontifex. M, Hillman. C, Fernhall. B, Thompson. K, Valentini. T, 2009, The effect of acute aerobic and resistance exercise on working memory, Medicine science sports exercise, Vol. 41, No. 4, pg. 927-934



**Reliability:**8 This source is immensely reliable as it is written by two credible authors, each with their credentials provided, proving that they are an expert in the field of interest. The evidence presented is supported by referenced information, as well as the source not having a bias. The only thing to question about this source's reliability is how current the information is. The journal article was written in 2002, although, due to the information primarily being about facts and the implications on the brain, facts don't change and so the stance on its reliability isn't altered.

**Source details:**8 Cotman. CW, Berchtold. NC, 2002, Exercise: a behavioural intervention to enhance brain health and plasticity, Vol. 25 No.6, Trends in Neuroscience, US

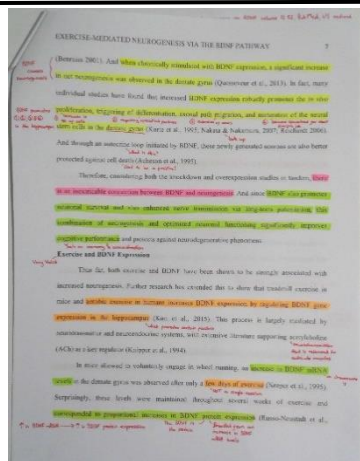
**Validity:8** This source is valid with information on how exercise contributes to the neuroplasticity of the brain. Furthermore, it also reveals the function of neurotrophic factors, particularly BDNF and IGF-1, and how these factors strengthen neuronal structures in the hippocampus. Thus, assisting me to answer my question. However, there must be consideration in the validity that the study was conducted on rats, not humans and so even though findings would be similar it is something to be kept in mind.

**Key findings:8** There are so many key findings in this source that have added great value to my research. A few of these include, BDNF and other growth factors actually stimulate neurogenesis, BDNF is the foremost factor that mediates long-term benefits of exercise on the brain and exercise strengthens neuronal structures facilitating synaptic transmissions and so activating cells for encoding information from the environment. These findings show that so many complex yet amazing processes occur when exercise is undertaken, many contributing to the improvement of memory.

**Leads:8** This source is full of leads to more complex and detailed information. Many of the leads from this source came from the references included in the article when are very helpful in that they will provide more detail on a particular section or idea. One lead that I would like to explore further is how other neurotrophic factors also contribute to improved memory because factors such as nerve growth factors (NGF) and fibroblast growth factor 2 (FGF-2) are also induced in the hippocampus in response to exercise.

**Conclusion on source:8** In conclusion, this source has been excellent in clarifying how BDNF works and underwrites enhanced cognitive function and neurogenesis. It is also extremely reliable, so the information contained will definitely be used in my outcome.

**Development of capabilities:8** By analysing this source I developed the critical and creative thinking capability because I advanced my knowledge and understanding of a range of concepts and scientific ideas. This is because this source had highly scientific vocabulary, so I had to understand the vocabulary before I could understand the concept. But, by doing this I gained a better understanding on the whole of the thoughts behind BDNF and how it works in the brain.



**Source details:9** Liu.P, Nusslock.R, 2018, Exercise-mediated neurogenesis in the hippocampus via BDNF, Vol 12 No.52, PubMed, US national library of Medicine National institutes of Health

**Reliability:9** This article provides little information on the authors, so it could be seen as unreliable. However, it is published by a respected and credible library which is operated by the US federal government and is the world's largest medical library. The fact that it specialises in health and medicine, which is the field of interest and of the article. This suggests that any published material on here would be trustworthy and the information can be used without having to be backed up by another source.

**Development of capabilities:9** The critical and creative thinking capability has been developed because I reflected on previous knowledge and identified that I needed to understand this concept better to understand the whole concept better. This source assisted me in this.

**Validity:9** This source is extremely valid and answers my question, even individual breakdowns of my original question. This source expands on how brain-derived neurotrophic factors (BDNF) promotes neurogenesis, how BDNF is functionally dependent on tyrosine receptor kinase (TrkB) and visa versa altering its expression levels. More significantly though, it explains how exercise increases levels of BDNF which is so prevalent in the hippocampus, the centre of memory function, in response to exercise. This source is very useful and its findings will be used in my outcome.

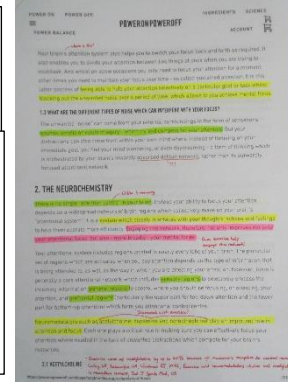
**Key findings:9** This source had a lot of significant information on neurogenesis and how exercise and BDNF, when going into more detail, is involved in the process. Neurogenesis consists of three essential components: multiplying of original neural cells, differentiation and expansion of axons and the maturation and integration of the final neural cells. An area where this occurs is in the hippocampus where BDNF expression strongly promotes this same neurogenesis process. Exercises increases BDNF expression, so it in turn can promote more neurogenesis in the hippocampus.

**Leads:9** This source has many open avenues which could be explored further, but in keeping to topics that are valid the avenue which would be most helpful would be to search up the autocrine loop that is initiated by BDNF. This is something which I haven't really touched on and yet, this loop seems to be central to what BDNF does in the dentate gyrus (hippocampus). Furthermore, it helps protect newly generated neurons against cell death, so surely this loop is another piece to the jigsaw and it will be interesting to find more about it.

**Conclusion on source:9** Overall, this source is reliable and valid in that it relates BDNF, which exercise increases, to neurogenesis such as increasing the hippocampal volume, thus improving memory. So, this chain has become a lot clearer by analysing this source. These findings will certainly be used in my answering my question.



**Source details:10** N.D, 2019, Brain balance guide-The neurochemistry of focus, <https://poweronpoweroff.com/blogs/longform/the-neurochemistry-of-focus>, Accessed 11<sup>th</sup> April 2019



**Reliability:10** This source's reliability can be heavily questioned as it doesn't provide a specific author and the date the article was written, but rather just has the company name and the current copyright date. Also, the purpose for writing is to explain how certain chemicals present in the supplement the company is trying to sell help to "power on" your mind and improve your mental focus and attention. Therefore, the credibility is uncertain and the information will need be to cross-referenced before being used.

**Validity:10** This source helps provide information which will give me leads to answer my question, but it doesn't answer my question directly, so its usefulness is limited. The article provides information on specific molecular compounds which intend to boost individual's attentional focus, however, if exercise doesn't influence these neurotransmitters then the material will be invalid.

**Key findings:10** There were three main neuromodulators: acetylcholine, dopamine and norepinephrine talked about in this source, as well as, ATP. Acetylcholine (ACh) stimulates muscarinic and nicotinic receptors, enhancing attentional focus. Dopamine helps focus attention in making sure that you pay attention and shift focus in a flexible and appropriate manner, based on information you have learned previously. Norepinephrine promotes arousal and activates wake-promoting cholinergic cells and inhibits sleep-promoting GABAergic cells. ATP is produced in greater amounts through exercise and is used to aid cognitive function on tasks requiring focused attention.

**Leads:10** This website was interesting and does have validity in that all the neuromodulators relate to attention and having sustained attention. Nevertheless, the vital next step would be to find out if exercise influences these chemicals by increasing their levels, decreasing their levels or by having some other effect on them. Only then would the information gathered be useful in answering the overarching question.

**Conclusion on source:10** Altogether, this source is unreliable and is only half way there to being totally valid, so the information will be used as leads rather than a solid foundation of evidence for answering my question. The specific leads used will be the individuals types of neuromodulators and their receptors that help rouse a higher level of attention.

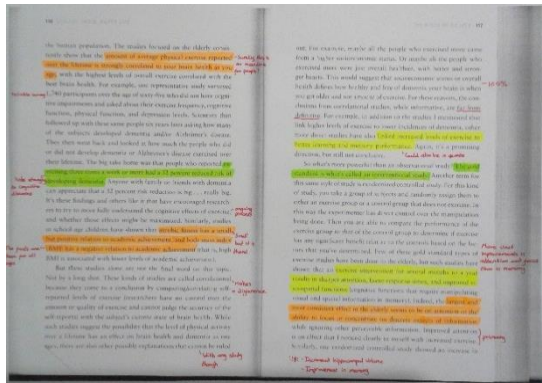
**Source details:11** Suzuki.W, 2016, Healthy brain, Happy life, Dey street books, US, pp. 116-117

**Reliability:11** This source had an amazing amount of credibility predominantly due to the authors credentials. Wendy Suzuki is a well-known neuroscientist who runs an interactive research lab at New York University. She holds a Troland research award from the national academy of sciences and is a two-time TEDx speaker. Her work is focussed on how the brain changes and adapts particularly in response to exercise and she has overseen personal and collective experiments.

**Validity:11** This source is extremely valid as its main focus is about how exercise improves ability to think sharper, increase memory capacity, work with greater focus and improvement in mood. The memory and focus sections are especially valid as these will help me answer my question. This source talks about how a variety of studies correlate exercise to good brain health.

**Key findings:11** The main key finding from this source would be that there are more vast improvements relating to attention and focus during and after exercise than relating to memory. Moreover, prolonged regular exercise for several months to a year results in sharper attention, faster response times and improved functions concerning visual and spatial information in memory. It also mentions how improved cognitive function is displayed with high levels of aerobic fitness having a small but positive relation to academic achievement. On the other hand, BMI has a negative impact on academic achievement. As well as, there being a huge decrease in risk pertaining to cognitive disorders.

**Leads:11** This source is great for leads and has really guided my thoughts and directed me to thinking more about the applications of having an improved memory as well as a greater ability to focus and concentrate on tasks. This is because this is what it is all about really, the benefits you can get from exercise are amazing and have a far greater weight than previously perceived. However, if they can be put to use in schools, at work or just in general everyday life, this is when it makes what exercise does even better. Therefore, I will have a greater focus on the applications of my findings.





**Conclusion on source:**11 Overall, this source has greatly helped me to understand scientific concepts better, as well as making sure that I apply the knowledge I gain to help make a difference rather than just having the knowledge and not doing anything with it. It also tremendously reliable and valid which means that I will unquestionably use the information in my outcome.

**Development of capabilities:**11 With this whole book source I have developed the critical and creative thinking capability because as I analysed, I asked a lot of questions particularly to do with how things can really be relevant to everyday life. The result being a much clearer understanding of information and ideas, specifically BDNF, memory in general and self-achievement.

**Source details:**12 Robinson. K, 2019, Exercise and the brain survey, conducted on 9<sup>th</sup> April 2019

**Exercise and the brain**

**Reliability:**12 This source is unreliable and can't be trusted, except in the case of just using the statistics for raw data about a general population. Its reliability should be questioned because when the students answered the question there was nothing to measure against, it is just whatever they feel. Also, there is no way to measure if the what they said is true and so I'm not able to take what they say on face value because there are so many other factors that could have contributed to them saying what they did. Hence, the majority of this source will be discounted when it comes to writing my outcome.

**1. How often do you exercise?**

- Daily
- 2+ times a week
- Weekly
- Monthly
- Nope, what's exercise

**2. What is your main type of exercise?**

**3. Do you feel on a high after exercise?**

0 of 8 answered

**Validity:**12 This source is valid because I wrote the questions so that they would be useful in answering my question. An example of this is, are you able to concentrate better after exercising? This is useful because if the 100 people surveyed do feel like exercise does help then all these journal articles may be true, but they aren't significant. Subsequently, this will alter how I answer my question.

**Key findings:**12 The main findings from this source is that 79% of people surveyed feel the “runner’s high” feeling after exercise, indicating that the can feel the brain working and doing something during exercise. Another point is that in general, people felt that they were able to concentrate much better after exercising, however, it was seen that more people felt that their memory improved more at 92%.

**Leads:**12 This source doesn't provide many leads as it is more a collection of quantitative data that will be used to support arguments rather than providing new arguments or ideas to explore further. Although, one of the questions related to participation in a case study, to which there was a good response. Therefore, it is now possible to get the involvement needed to conduct a case study, but factors such as how data is going to be collected will be difficult to negotiate as it is such a scientific and detailed topic.

**Conclusion on source:**12 Overall, this source provides a good lead into conducting a reliable case study in terms of randomised participation of school-age students and is a valid source. On the other hand, it is unreliable and the material from the sources isn't dependable. Consequently, the source will be discounted for one or two or the statistics provided which give an indication about how the general population behaves in response to exercise

**Systematic review**

**Organisation of key findings:**

Throughout this research process there have been many sources analysed and a lot of information read from different points of view, different backgrounds and different types of sources. Therefore, in order to understand the important parts of each source it is important to synthesise the material into a few key findings. To do this I read through the sources to get an overall picture of what it was talking about before going through and highlighting the main ideas. By using a highlighting system across all sources, it was a lot easier to simplify the information to the core ideas helps bring out what the major factors are in answering my question.

#### Common ideas amongst the sources:

This research process has greatly enhanced my knowledge about the effect of aerobic exercise on memory and concentration. Exercise has many drastic effects on the brain and chemicals within it including: Increasing the size and therefore volume of the hippocampus, creating new neurons, increasing blood flow to the brain and encouraging the production of neurotrophic factors and growth factors. The main neurotrophic factor is brain-derived neurotrophic factor which is the key factor to improving memory. This is significant in my research because I didn't know anything about BDNF before I started and now my whole argument has BDNF involved. Furthermore, another key branch is that exercise promotes improvement in cognitive function, subsequently leading to enhanced academic achievement.

#### Cross referencing:

Cross referencing is vital to understanding what information reliable, common and scientifically based compared to what only one source is stating and therefore may not be true. This is clear to see by highlighting common ideas amongst the key findings (see text box left). This was done by recognising the key words that were repeated in the list of key findings and highlighting ideas that agreed with one another. The points that weren't highlighted will have to be looked into whether that particular source was reliable or not, as to whether the information is used in my outcome.

#### Conclusion on sources:

Overall, the sources that I analysed were mostly reliable and valid. This aided my research a lot because I knew that I could trust the information that they were presenting and that it can be used in my outcome. Also, it means that even if the information wasn't among the common ideas highlighted it can still be used because the source is credible and there wouldn't be false information contained in it.

#### Follow up of leads:

As I went through the sources, it was important to note any possible leads that could be explored further. This included things such as new ideas that previous sources hadn't mentioned or referenced sources that may potentially have more detail on a certain topic or even that a theme was starting to appear amongst the sources so further research was needed on the topic. This helped me get a clearer understanding on certain topics such as the influence of brain-derived neurotrophic factors (BDNF) and growth factors, in particular IGF-1 and how exercise impacted these factors. Without following up on leads, my research would have been fragmented and all over the place emphasising the importance of following through with ideas.

#### Development of skills:

Throughout this process I developed many skills, some I grew in confidence in and some I attempted for the first time whilst analysing and compiling sources. I improved in my ability to skim-read a source to ascertain whether or not the source was worth analysing based on its reliability and validity. Some sources were clearly invalid, even though they appeared to be on the topic, therefore they were not analysed further. I also developed the skill of talking and asking questions to people to try and consolidate my research. At first, I was nervous and unsure of how to go about it, but in the end, I went out and now I feel more comfortable interacting with people I don't really know. I also improved in analysing information displayed in a variety of representations to deepen my understanding of how the quantitative data presented influenced the topic. Furthermore, I asked a lot of questions whilst analysing sources, expressing my opinion and being ready to take different perspectives into account. This advanced my skill in higher-order thinking as it meant I had to think and question on a much deeper level to understand the overall picture better. Overall, there are so many areas where I have improved on that I can now implement in other areas of academia but also in life. These skills can now be worked on further to gain confidence in them and get better at many different areas.

#### Development of capabilities:

The research process has been a journey of development of my skills and knowledge. During this process my focus was on developing the critical and creative thinking capability which I developed by a lot of critical, logical, ethical and reflective thinking on the decisions I made, the sources I analysed and the what my next steps were going to be. I also developed it by recognising how knowledge changes and is influenced over time. Considering that my topic is a new, scientific topic which will continue to advance as new research is unfolded, it is important to grasp that this is the answer at this stage. The facts won't change but it is inevitable that in the coming years new, ground-breaking research will be published and could possibly enhance the importance of the topic. As I studied sources, I developed in my ability to learn and then apply new knowledge straight away. This meant that ideas, such as learning about BDNF and growth factors, altered the way that I then progressed with my research. If I had stuck to the same path as originally planned, I wouldn't have explored the many, crucial concepts that this topic has to offer, limiting my outcome. Finally, before I started this project I wasn't very good at justifying my thinking and reasons for choices I took. However, this process has matured this specific capability and now I am much more capable of explaining my thinking and identifying reasons for why I have taken certain actions. This has contributed to being able to learn from each source to build up a clearer bigger picture.