How to Write a Research Paper

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How to Write a Research Paper
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Contents

Definition: 'Ones' true love' – a person who will stand by your side while you walk through the gates of hell to fight a horde of demons.

"To Janice who stood by my side and to Cara for whom we fought"

My thanks and very best wishes go to Muhammad Hussaini, Molly Sturman and Shaun Watson, former students who were kind enough and brave enough to give me permission to display and dissect their work. Thank you!

Simon Kendal

Foreword

This book aims to develop the practical and analytical skills needed to write a good research paper or a research chapter in a dissertation – assignments that many undergraduate students at University face.

These skills include:-

- Understanding the difference between a research paper and an essay.
- Helping you develop ideas for your research paper.
- Learning how to find the research papers you will need.
- Looking at actual research papers to develop your understanding of the contents.
- Develop an understanding of research methods, experimental design and bad science so you will have the skills to evaluate research for yourself.
- Develop the writing skills needed to write your research paper.

The practical skills will be developed by small exercises that the reader will be invited to undertake and the feedback that will be provided.

The concepts that will be explained and skills developed are important for any undergraduate student and even more important for those students studying higher degrees, M.Sc.'s or other such courses, where an advanced understanding of the subject and advanced academic skills are expected as standard.

Many books already exist to help with basic writing skills or even academic writing. Unlike those texts this book will focus solely on the skills required to write a research paper.

This is not a theoretical textbook but a learning tool help you develop the practical skills required. To this end each chapter will incorporate small exercises with solutions and feedback provided.

At the end of the book, in Appendix 1, three complete research papers are presented. These were written by undergraduate students and will be used to illustrate the application of the techniques explored in the earlier chapters.

This book will start by explaining basic research concepts, as understanding these are important if you are to write about research, but while doing this unnecessary research jargon and Latin terms will be avoided…other books explain the differences between induction/deduction and abduction and other principles of logic and reasoning should you wish to take this topic further.

Finally this book is not designed to help professional researchers write their own research paper as the skills involved in describing primary research are not entirely the same as those involved in writing a survey paper i.e. a research paper that evaluates the work of other researchers.

Novice researchers can decide for themselves if they will gain some benefit from the chapters of this book that develop an understanding of good scientific principles and from the chapter that looks at the structure of well written research papers.

1 Just What is 'Research' Anyway?

Introduction

This chapter will discuss basic research concepts as many students seem to have misconceptions regarding the word 'research'. Clearing out these misconceptions and understanding the basics of research theory is important if you are to understand how to write a research paper or write a research chapter for a dissertation.

The tasks of writing a research paper and of writing a research chapter, as part of an undergraduate dissertation, are in many ways very similar thus if you are required to write a research chapter this book should still help you.

Objectives

By the end of this chapter you will be able to…

- Explain what research is,
- Understand the basics of research theory,
- Understand the critical difference between books and research papers
- Understand what constitutes a good quality source
- Understand what is involved in writing a research paper

All of these issues will be expanded on in the later chapters of this book which will endeavour to develop the practical skills needed to write a research paper.

This chapter consists of 13 sections:-

1) Research – A Common Misunderstanding
2) What is Research?
3) What is Knowledge?
4) A Simplified Scientific Process
5) A Hypothesis…a Testable Theory
6) The Differences between Research Papers and Books
7) Research Papers are Scary
8) The Differences Continued
9) Good Quality Sources
10) Research Sources Ranked in Decreasing Order of Quality
11) How You Demonstrate the Use of Good Quality Sources

12) How to Write a Research Paper
    - Step 1) Determine the Question
    - Step 2) Critically Evaluating the Research
    - Step 3) Comparing Different Theories or Methods
    - Step 4) Applying the Theories or Methods
    - Step 5) Write your Research Paper
13) Summary

1.1 Research – A Common Misunderstanding

Many students seem to come to University misunderstanding the concept of research and probably for very good reasons. They also seem to have often picked up some very bad habits from school or college and these bad habits can cause very serious problems for students at University.

This misunderstanding and bad habits significantly impact on a student's ability to write a research paper.

…So let's start by fixing this now!

Activity 1

Think back to your time at school or college – for you, unlike me, this probably won't be ancient history – and answer the following questions Yes or No.

1. Were you ever asked to go and find out some information for yourself either from books or, far more likely these days, from the web?
2. Were you ever asked to prepare a presentation, perhaps on a subject of your choice, which involved Googling the subject?
3. Did your teacher ever use the word research to describe this activity as in 'Go and research it for yourself'?
4. Did you ever find yourself cutting and pasting text from web pages into a report or into a PowerPoint presentation (be honest – I won't listen to your answer)?

Activity 2

Given your answers above would you accept the following definition of research as a valid definition…'A search for information, facts or knowledge'?

Feedback 1

From my experience many students at school are asked to go and research a subject for themselves by searching for information from the web.

In some cases students are pointed to very useful sources such as Wikipedia though students are also sometimes warned the web is not always a reliable source.

Still the web presents a vast collection of information. Want to know when Columbus set sail for America (he didn't actually)? – Google it. Want to know the difference between an alligator and a crocodile? – Google it.

…Other search engines do exist.

Want a simplified explanation of a 'Lunar eclipse' or the physics of a 'Rainbow' – go to Wikipedia (even if this isn't always 100% accurate).

Finding information is an essential life skill and the information available via the web is vast and modern tools make accessing this very simple…if you doubt this try using a 100 volume, hard back, print based encyclopaedia which is expensive to buy, very heavy to move, slow to search and far more limited in its content than the web.

Don't worry if you have never seen a print based encyclopaedia – they were probably well before your time. You may want to find one in a museum somewhere just so you can appreciate that life before the web did exist.

Given the web is a vast information source and given finding information is an essential life skill it is not surprising that teachers often tell students to go and find out for themselves…and quite often they do so by telling students to go and do their own **research** on the subject.

Feedback 2

Given this you may think that research is indeed 'A search for information, facts or knowledge'.

Teachers often badly misuse the word 'research' and thus it is not surprising that students come to University thinking their job is to find information and present this information in a research paper but this is not the case.

Writing a research paper is **not** at all about finding out and summarising information.

…and if you don't understand what this task is how can you hope to do it well?

Many students think that writing a research paper means presenting the 'information, facts or knowledge' they have found.

But in fact you would be quite wrong to accept this definition of research and students who write research papers that do little more than present information are essentially **failing**.

Finding information **is not research** no matter how difficult or impressive the subject.

If you were to write an essay, and note I use the word 'essay' here – not a research paper – explaining in detail how a computer encrypts information I would be quite impressed as this is not a simple topic. I would be especially impressed if you could explain the differences between different encryption methods and explain which method is best and why. By all means write a very good essay on the subject for me… if you could do this well I would enjoy reading it.

…but no matter how complex the topic, or how impressive your essay is, finding information is not research and thus presenting a summary of this information does not make your essay a research paper.

So if this isn't research what is?

1.2 What is Research?

Doing 'research' at University means something quite different than doing 'research' at school.

Activity 3

Watch the 3 minute video 'What is research?' by John Earnshaw posted on YouTube at https://www.youtube.com/watch?v=BJhpQs82uR8

Feedback 3

This video very helpfully highlights the gaps in our knowledge i.e. the '?'s

And it also highlights the fact that research is an activity…doing something other than reading…to move the boundary.

…and by 'our' we mean the whole human race; i.e. there are things our entire species has yet to learn, problems that we as a species have yet to solve…

To do 'research' means doing something to find out something that no one else knows i.e. solving problems that no one else has yet solved.

Research is not about us finding out something that someone else knows – **research means pushing forward the boundaries of human knowledge**.

Finding out information is essentially a task of searching for information and reading.

Research is a very different task. It is active i.e. it means doing something that will enable you to discover new knowledge. In other words it means doing something that will let you learn something that no one else knows…and then writing about it so you can tell others what you have discovered.

Thus if you are writing a research paper you need to do something that is far more than just finding and summarising information – you need to do something that will enable you to discover something new…but what is this something that you need to do?

Before we answer this it will help if we understand a little more about knowledge…after all we have just said that research is about pushing forward the boundaries of knowledge…so we must first understand what knowledge is. After that we can learn what researchers do. Then you will learn what it is you must do in order to write a good research paper.

1.3 What is Knowledge?

Plato, *who lived quite a long time ago*, defined knowledge as 'true justified belief'.

Activity 4

Think about something you firmly believe is true but cannot prove.

Now think about something that someone else firmly believes but that you do not agree with.

Feedback 4

Personally I believe I am witty, charming and handsome…but I don't think everyone agrees with me.

You may absolutely believe, without a shadow of doubt, in the existence of God and you may indeed be correct. In support of your beliefs you may note the wonders of the Universe and the miracle that is life…but you cannot prove that God exists.

Others may believe with equal fervour that God does not exist…and perhaps it is they who are correct. In support of their beliefs they could present a discussion of science and evolution etc.…but they equally cannot prove that God does not exist.

Just because we firmly believe something to be true does not mean we know it to be true.

Plato's definition of knowledge can be presented graphically:-

In other words:-

- There are many beliefs which are not necessarily all true
- There are many truths, not all of which are known or believed
- Among those beliefs which are true only a subset has been discovered and verified and it is this subset that counts as knowledge

Therefore, according to Plato's definition, we cannot say we **know** something unless we can justify this i.e. present incontrovertible evidence.

Thus if research is about pushing forward the boundaries of human knowledge it must mean that research involves a) discovering new truths and b) finding evidence to verify these truths.

But how can researchers do this?…and if this is required to write a research paper how can you do this?

To answer these questions we need to consider the basics of a scientific process.

1.4 A Simplified Scientific Process

People used to believe the Earth was flat and that the sun revolved around the Earth and they believed this for very good reasons.

They could see the sun rise in the morning, cross the sky during the day and set at night. They were told about heaven and hell, at least many people were taught about this along with the existence of God… God must have existed to create the sun etc, Heaven and Hell were reasonable suppositions given this and heaven was somewhere up above the clouds…hell was somewhere down below…beneath the Earth.

If the Earth was not flat, where was heaven and hell? and what stopped people on the other side of the world from falling off?

For these reasons many people believed the Earth was flat but now most would say they **know** the Earth is round. So how could we come by this knowledge?

We came by this knowledge by following a process of scientific discovery…commonly called research,

This process follows three simple steps.

1) Observe something that can't be explained by our current knowledge.
2) Provide a suggested explanation for this phenomenon…we call this suggested explanation a hypothesis.
3) Test the hypothesis to find out if it is really true.

Remember 'true justified belief' – we need to test our theory in order to verify it – so step 3 is very important.

Activity 5

Assume we have a hypothesis that heavy things fall faster than light things, think of a test we can do to prove this.

Feedback 5

To test this you may have thought to take a stone and a feather up to the top of a tower and dropping them both at the same time to find out which will get to the bottom first.

In fact this would be a very bad test. A feather is not just lighter than a stone it also has a much higher surface area and this causes friction which slows the feather down.

This brings us to a very important point:- our test, which we will call an experiment, must be a good and fair test. We will come back to this point later.

Activity 6

How about a different test? What if we were to take two virtually identical bricks, where the only differences were that one was made up of a light material and one was made from a dense material, and we then dropped these bricks at the identical moment and from an identical height?

Would this be a fair test?

Feedback 6

We would call this a controlled experiment. A controlled experiment is where we have a control test…in the case of the light brick that is identical in all other respects to the heavy brick.

As the only difference is the weight of the brick…not its size shape or anything else we can be sure that if the bricks are to fall at a different rate then it is the weight that causes this.

You may want to try out this experiment…just be sure no one will walk underneath the falling bricks.

Coming back to our simplified scientific process…1) observe 2) develop a hypothesis 3) test our hypothesis.

So, assuming we believed the Earth was flat as many people did, what could we have observed that would lead us to hypothesise that the Earth was round? and how could we have tested this theory?

1) If the Earth was flat a sailor would be able to see all of another ship at the same time no matter where they were on their current ship. However sailors noted that they could see the top of other ships before they could see the deck. Sailors also noted they could see better from the top of the mast – hence why they built a crow's nest there for a lookout.

Line of sight from ship's deck and from the top of a ships mast.

2) From this observation, which doesn't fit our belief that the earth is flat, we could develop a hypothesis that the Earth was round as this would explain the observations. We could of course develop an alternative theory such as a sailors eyesight improves as they get away from the sea spray…and if this was our theory then we would need to find a way of testing a sailor's eye sight. But let us proceed on the theory that the Earth is round.
3) We could test this hypothesis by setting off to sail around the world as Ferdinand Magellan did in his expedition of 1519–1522 which was the first to circumnavigate the Earth. This would surely prove that the Earth is round.

So a simple scientific process is 1) make observations 2) develop a hypothesis 3) test the hypothesis.

In fact the question of the shape of the Earth was settled long before Magellan's expedition of 1519 – it was proven by a very clever astronomer and mathematician, Eratosthenes of Cyrene who lived approx. 200–300 BC…almost 2000 years before Magellan's expedition.

Eratosthenes not only proved the Earth was round he determined how big it was.

Activity 7

Watch Carl Sagen's video on Eratosthenes at
www.youtube.com/watch?v=G8cbIWMv0rI

Lasting less than 7 mins this is an excellent video that demonstrates the scientific process we have discussed.

Feedback 7

This video highlights several important issues…

1. The data we are basing our work on must be accurate i.e was there really no shadow at the bottom of the well? We will return to this point later.
2. The data disproved the previous belief that the Earth was flat…so Eratosthenes came up with a new hypothesis that the Earth was round. Actually previous scientists had already suggested this was likely based on the changing shape of the moon's shadow but Eratosthenes went further and based on the data he calculated the circumference of the Earth with a fair degree of accuracy.

Activity 8

Think about this video – one crucial step in our scientific process is missing (make observations – develop a hypothesis – test the hypothesis). Which step is not discussed in this video?

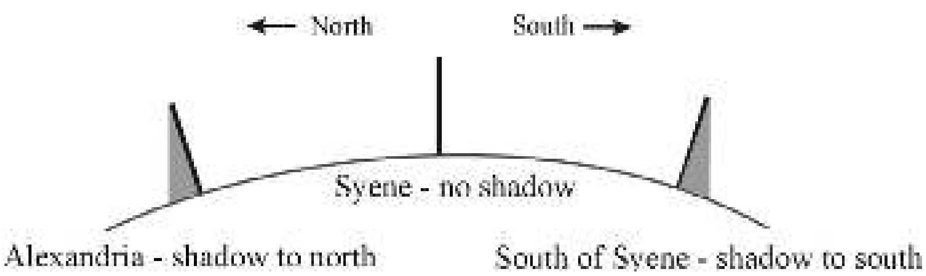
Feedback 8

Eratosthenes came up with a new hypothesis that the Earth circumferences was approximately 40,000 km – but the video does not highlight how this hypothesis was tested – step 3 in our simplified scientific process.

Until we test the theory it is just a theory. We cannot claim to know the circumference of the Earth unless we test the theory and verify the theory is correct.

We could test this hypothesis by asking someone to walk around the Earth and measure it but this would be very difficult given the Pacific Ocean is in the way. So we would need to find a simpler way to test this theory.

If Eratosthenes model of a round Earth is correct, as suggested by the shadow cast at Alexandria when no shadow was cast at Syene (800 km to the south), then we could make a prediction that going 800km south of Syene a shadow would be cast equal in length to the shadow at Alexandria but in the opposite direction.



If we tested this prediction and the prediction is correct it would imply Eratosthenes hypothesis was accurate i.e. that the circumference of the Earth is 40,000 km.

We would have verified the hypothesis and thus we could say we know the circumference of the Earth.

Making predictions based on a hypothesis is a good way of testing it. If the prediction proves to be accurate this lends evidence to support our hypothesis.

1.5 A Hypothesis…a Testable Theory

Activity 9

Assume we have a hypothesis that God exists…can you think of a way to test this?

Feedback 9
It is extremely difficult to come up with a simple, clear and incontrovertible test either to prove God exists or to prove God does not exist.

The definition of a Hypothesis is a 'testable theory'…If we can't devise a test then we don't have a hypothesis – we only have a theory that science can't prove. In other words we can't claim to know the answer. Therefore while we may think God exists, or we may think God does not exist, but until we can devise a way to test this we cannot say we have a hypothesis regarding the existence of God.

1.6 The Differences between Research Papers and Books

So far we have looked at research – the process of pushing forward the boundaries of human knowledge. But research is of no value if in the end it is not published.

Researchers publish their work in research papers in order to tell other researchers what they have discovered.

In order to begin to understand how to write a research paper you must understand the differences between research papers and books.

Furthermore as research papers are quite different they are used quite differently.

Activity 10

One very current and interesting research topic is the research being done to make cars that do not require a human driver – completely autonomous cars.

If you want an easy to read article that explains a) the advantages offered by autonomous cars, b) the progress that has been made in this area and c) the work left to do follow the link below to an article published on techradar.com…

http://www.techradar.com/news/car-tech/google-s-self-driving-cars-are-smarter-but-they-re-still-not-smart-enough-1245968

Feedback 10

There is no feedback for this activity.

Activity 11

Below are the details of four research papers that describe some of the research being done to make cars that do not require a human driver – completely autonomous cars.

Also provided are links to the papers themselves, found via Google Scholar.

We will look at Google Scholar later and learn how to find papers on a subject area of your choice.

For now follow the web links and download the papers.

The papers are very complex so don't bother reading them. Instead just look at the layout of the papers, the headings and the structure and consider if or how research papers are different from textbooks.

Research Paper 1

Cho, H., Seo, Y.W., Kumar, B.V., & Rajkumar, R., 2014, 'A multisensor fusion system for moving object detection and tracking in urban driving environments.', *In Proceedings of the IEEE Conference on Robotics and Automation*, pages 1836–1842.

http://www.cs.cmu.edu/~youngwoo/doc/icra-14-sensor-fusion.pdf

Research Paper 2

Vu, Trung-Dung; Aycard, Olivier; Tango, Fabio, 2014, 'Object perception for intelligent vehicle applications: A multi-sensor fusion approach,' *Intelligent Vehicles Symposium Proceedings*, IEEE , pages 774–780, 8–11 June 2014.

http://hal.archives-ouvertes.fr/docs/01/01/95/27/PDF/main.pdf

Research Paper 3

Wei, J., Snider, J.M., Gu, T., Dolan, J.M., & Litkouhi, B., 2014, June, 'A behavioral planning framework for autonomous driving', *In Intelligent Vehicles Symposium Proceedings*, IEEE, June 2014, pages 458–464.

http://www.ri.cmu.edu/pub_files/2014/6/IV2014-Junqing-Final.pdf

Research Paper 4

Wang, C., Zhang, H., Yang, M., Wang, X., Ye, L., & Guo, C., 2014, 'Automatic Parking Based on a Bird's Eye View Vision System', *Advances in Mechanical Engineering*, Article ID 847406.

http://ade.sagepub.com/content/6/847406.full.pdf+html

Feedback 11

The feedback on this activity will be provided later.

1.7 Research Papers are Scary

If you looked at the research papers above you may have thought these papers look scary…***they certainly look scary to me***. In fact they don't really look like they were expected to be read and understood by normal people (I am presuming you don't mind being classed as a normal person).

You may also be a little daunted or worried if you feel you are expected to write something like one of these…if so the most important message to take away from this is ***don't worry***.

It is true that writing a research paper is a complex and very academically challenging task, but it is not an impossible task – the proof of this is at the end of this book where there are three research papers written by students…student's who initially had no knowledge of research at all.

> **If they can do it so can you – it just takes hard work!**

The whole purpose of this book is of course to help you and there is one reassurance you can take note of now…

> If the task of a research paper was to explain in detail an incredibly complex theory then you would need to really understand that incredibly complex theory. However the purpose of a research paper is not to explain the subject but to discuss and evaluate the research process therefore to write a research paper does not require an in depth knowledge of the specific subject. What it does require is a basic knowledge of a sound scientific research process.
>
> **So writing a research paper is not as difficult as it may first appear.**

1.8 The Differences Continued

Going back to our consideration of the differences between research papers and books…

Feedback 11

We will learn how to look at and analyse the content of research papers properly later as this is an essential task if you are to successfully write your own research paper.

For now we will settle for a superficial look at the structure and content….

The research papers are obviously much, much shorter than books, often 5–10 pages long, though some research papers are longer than the ones we have viewed.

The structure of the papers is quite different from books…They are often, though not always, presented in a two column format and they don't have a table of contents or different chapters…though they do have different sections.

They have an abstract at the start and a list of references at the end.

Unlike a text book the research papers are on one extremely focused, and in this case extremely complex and technical, subject.

Unlike a textbook, that may explain general theories or concepts, these research papers describe some actual work done on one specific project.

If you looked at the headings you may have noticed that these papers seem to follow our simplified scientific process…
they describe some complex theories (ie a hypothesis),
they describe some experiments and results…(i.e. how the theories were tested),
and based on this they reached conclusions…(i.e. claims for new knowledge that push forward the boundaries of human knowledge).

These papers may, in the conclusions, also highlight problems still needing to be resolved i.e. further research that needs to be done – this is common.

Activity 12

Decide which of the statements below apply to text books and which apply to research papers (you may wish to write 'book' or 'research paper' next to each statement):-

1. These are written for professionals working in that field
2. These are written for students to learn from.
3. You can find alternative sources that describe much the same information
4. They will explain basic concepts or terms
5. They may explain the historical origins of the subject
6. They may explain the work done by many individuals, not always named.
7. They explain the work done by a very few individuals (the authors)
8. They may explain the work done by just one individual (the author)
9. If they explain work done they should explain in detail how the work was done.
10. They make claims that may never have been made before
11. They should present evidence to support the claims made

Feedback 12

1. These are written for professionals working in that field

   Research papers are not written for students, though Universities often expect students to read them and engage with research. They are written for other researchers who want to understand what has been done so far and want to understand what problems still needs to be solved. Research papers are also written for professionals who want to take the state of the art theory and apply this theory to a real world problem.

2. These are written for students to learn from.
3. You can find alternative sources that describe much the same information
4. They will explain basic concepts or terms
5. They may explain the historical origins of the subject

   2–5 all apply to textbooks. Textbooks are written to explain and teach. Many textbooks often exist on the same subject. The depth and complexity of them will often differ so you may find one textbook meets your needs better than another (just as there are other books that teach academic writing skills that you may, or may not prefer, over this book). Because of this textbooks often explain basic concepts and terms and sometimes present an interesting, though out of date, historical perspective of the subject.

   Research papers don't explain basic concepts or terms and rarely provide a historical perspective. They are written for other researchers and professionals who already have an in depth knowledge of the subject. Research papers do however usually provide a research perspective of the work presented i.e. they briefly mention other research that has been done in the field, or is ongoing, and they explain how the research described in this papers builds upon and fits in with the other research being done.

6. They may explain the work done by many individuals, not always named.

   Textbooks cover a wide subject and in doing so often explain theories, concepts and methods developed over a period of decades by many people other than the authors. As such it is often not possible to attribute the work to many of individuals involved though sometimes individuals who have made a very significant contribution are named. These are often not the author of the textbook.

7. They explain the work done by a very few individuals (the authors)
8. They may explain the work done by just one individual (the author)
9. If they explain work done they should explain in detail how the work was done.
10. They make claims that may never have been made before
11. They should present evidence to support the claims made

    7–11 all apply to research papers. Research papers by contrast describe one research project undertaken by a very few individuals – usually the author or authors of the paper. Because they are describing this one small piece of work they should describe clearly what was done and how it was done. Based on the evidence they present research papers should end by making claims for new knowledge – remember this is the goal of research – though they can, and often do, highlight gaps that still remain in our knowledge.

By analogy you could think of a book that teaches you how to cook, how to choose your equipment, basic techniques of food preparation etc. as a textbook…and a recipe, which explains in detail how to cook one specific thing, as a research paper.

…don't push this analogy too far.

Activity 13

Given all this consider…

1. Which would you trust more a research paper or a book?
2. Should you trust them or is it good not to trust them?

Feedback 13

Books usually describe established knowledge that many people would agree with though clearly old theories, methods and techniques are replaced by newer theories, methods and techniques. So the content of books do become out of date though usually this is a slow process over a period of years or decades (depending on the subject).

As children we learn to accept as true well established and reputable sources of information…our parents, our teachers and text books. We trust these sources of information and it is good to trust these sources of information. If you didn't trust anything you were ever told you would be dysfunctional and probably classed as paranoid. How often have you heard words to the effect 'it must be true I read about it'…though you may have reason to doubt some written sources of information e.g. some newspapers, gossip magazines and the web.

In much the same way as you may distrust some written sources **you should distrust research papers…all research papers!**

Research papers present the conclusions reached by a very small group of individuals – sometime they have plenty of good evidence to support their conclusions but sometimes this is not the case. You should not trust the conclusions presented in a research paper but instead you should evaluate the evidence for yourself. That is why good research papers present a detailed and clear account of the work that was done and the results so you can evaluate the evidence for yourself.

The information in research papers can also become out of date much more quickly than the information presented in books – some theories can quickly be proved to be incorrect or improved. Thus, while some older papers are still very valid, we should always look for the most up to date and recent papers on a subject.

The most critical difference between books and research papers is that you should not trust what you read in a research paper but you should instead evaluate the evidence for yourself.

Other researchers expect you to distrust them and question the validity of their conclusions. They welcome the fact that you will probe their research as this will help to ensure their conclusions are valid.

As this is such an important topic we will come back to this shortly and indeed devote an entire chapter to this later.

1.9 Good Quality Sources

Activity 14

Consider the following scenario…a person you have never met before and are unlikely to meet again offers you a new high quality television, normally costing £2000, for half price. The person says it comes with a 5 year guarantee.

Would you buy the TV from this person and save yourself £1000 or would you prefer to buy from a reputable shop that has a history of good service for the full price?

> **Feedback 14**
>
> If you buy the TV from the person you have never met before you are taking a risk. The 5-year guarantee is worthless if the person won't be around to honour the guarantee. Worse still the TV could of course be stolen property!

You take a risk if you don't buy your goods from reputable sources…in much the same way you take a risk if you don't use reputable sources for your research.

Furthermore your readers will know whether or not you have used good quality sources and you will be judged on the quality of the sources you use.

1.9.1 Textbooks

Textbooks can be very high quality sources of information but they don't describe research so for the purpose of writing a research paper they are almost completely useless…there are a few exceptions.

There are exceptions…a research student who has done a PhD at university, a 3-year research project, will normally have written this up in a book called a PhD thesis. While this is a book this would be considered a high quality source of research information.

Some books contain a collection of good quality research papers…these are not normal textbooks and you would not normally refer to the book as a whole but cite one of the specific papers within the book.

1.9.2 The WWW

The Web is an extremely unreliable source of information as anyone can publish anything on the web in a matter of minutes. Though you can find out very up to date information/news from the web it is the most unreliable source of information you can use.

If you are writing about research being done in the area of computer security and you want to demonstrate that this is an important topic you may show, as an example, details of a particular company who had their security breached. Citing a widely reported news web service as a source for this information is fine but for most research purposes web references should be avoided.

1.9.3 Formal standards and Government papers

Formal standards are published by government and professional bodies that are authoritative and reputable. These include cover software, engineering, medical, ethical and legal standards.

While these are authoritative and reputable they are not about research and are therefore not good as a primary source of information.

Of course if you are discussing research to improve one of these standards then of course it is legitimate to refer to the standard itself.

1.9.4 Refereed Journal and Conference Papers

Refereed Journal and conference papers are the best quality source of information you can use.

Journals are books that contain a collection of research papers on one general topic. The same journal will regularly publish papers on the same general topic – each version will therefore have a different year or volume number associated with it.

Conference proceedings are very similar to journals. Research conferences are held regularly throughout the world. These are attended by hundreds, and in some cases thousands, of researchers. Each researcher will give a presentation about their research after which they will be expected to answer questions. After the conference the papers are published in the conference proceedings.

An important point to note here that the papers in journals are checked, **refereed**, before they are published…and the best quality conferences also get the papers refereed first to check for quality.

This is very similar to the process you may follow when applying for jobs. Prospective employers often ask for references and someone who knows you will be expected to say how good your skills are and how motivated you are etc.

In much the same way papers are checked. To ensure the process is fair and not open to bias research papers are anonymised by removing the author's names and then a group of academics in that subject area will decide if the research paper is good enough to publish.

Not all conferences follow a rigorous referee process so some are better than others. It is not easy to know which conferences and journals are the best in terms of quality until you start to publish research papers in your subject area. Generally though, while some are better than others, journal and conference papers are the best quality research sources you can use.

1.9.5 Professional Magazines

Some professional bodies are heavily involved in research and support and fund research conferences and publish numerous journals. These often also print magazine versions of full research papers. In many respects these are almost as good as research papers published in journals but the language and explanations are made simpler – thus for novice researchers these are an excellent starting point and source of information.

1.10 Research Sources Ranked in Decreasing Order of Quality

Activity 15

Reorder the following list putting the highest quality research sources at the top and the lowest at the bottom.

Conference paper
A web page
Journal Paper
A text book
A PhD thesis
A formal published standard
A research paper in a professional magazine

Feedback 15

Journal Paper
Conference paper (some of these are as good as the best quality journals)
A PhD thesis (also excellent quality)
A research paper in a professional magazine (almost as good and a very good starting point)
A formal published standard (good quality but not for research)
A text book (can provide good explanations but do not describe current research)
A web page (good for current news but not a refereed source of research information)

To summarise this you will be judged on the quality of the sources you use:-

Journal and conference papers are the best quality source of information you can use.

Textbooks and web pages should be avoided as much as possible.

1.11 How You Demonstrate the Use of Good Quality Sources

Activity 16

Consider the following two research papers and decide which came from the best quality source:-

Research Paper 1

'A multisensor fusion system for moving object detection and tracking in urban driving environments.' http://www.cs.cmu.edu/~youngwoo/doc/icra-14-sensor-fusion.pdf, date accessed 1st June 2014

Research Paper 2

Cho, H., Seo, Y. W., Kumar, B. V., & Rajkumar, R., 2014, 'A multisensor fusion system for moving object detection and tracking in urban driving environments.', *In Proceedings of the IEEE Conference on Robotics and Automation*, pages 1836–1842.

Feedback 16

These papers are in fact the same paper. This was one of the papers you looked at in earlier in this chapter.

Notice how the second reference highlights the name of the conference the research papers was published in – highlighted in italics – and those who know would recognise the IEEE is a very reputable source.

From the first citation we would only know that it was a web page and therefore **we could only presume it was a poor quality source**.

It is therefore very important that you provide a correctly formatted reference list that describes all of your sources and highlights the name of the journal or conference a research paper was published in.

There are different standards for writing a reference list. Two of the most common are the Harvard standard (where the sources are listed alphabetically by author) and the British standard (where the sources are numbered).

Even within these standards there are slightly different formats and you should follow any publication instructions you are provided with.

My preferred format, when referencing research papers, is the Harvard format where you provide the following details:-

> The names of the authors, the year the paper was published, 'the title of the paper in quotes', *the title of the journal or conference in italics*, the volume number and page numbers (see paper 2 in the exercise above for an example of this).

Activity 17

Consider a bill that has arrived. You need to pay your rent by a specified date otherwise you will be threatened with eviction.

Does it matter most how the bill arrived (mail or email) or are the details of the bill far more important (i.e. how much the bill is for, who must be paid and when it must be paid by)?

Feedback 17

The details of the bill are far more important than how it arrived.

In much the same way if we find and use a good quality research paper it is irrelevant how we obtained this paper (via the post, via a library or, more commonly these days. via the web) but it is very important we show it was published in a journal or conference (the best quality source).

Some people when providing a reference to a research paper will provide additional details at the end including the web site where the paper can be found. They do this to make it easier for the reader to find the same source should they wish to do so.

E.g. for the paper above this would be…

Cho, H., Seo, Y.W., Kumar, B.V., & Rajkumar, R., 2014, 'A multisensor fusion system for moving object detection and tracking in urban driving environments.', *In Proceedings of the IEEE Conference on Robotics and Automation*, pages 1836–1842. http://www.cs.cmu.edu/~youngwoo/doc/icra-14-sensor-fusion.pdf

While this is perfectly OK it does take the focus away from the name of the conference or journal and could confuse a reader if the reference is badly formatted. The reader could think this is just a web page – the lowest quality source.

As you are judged on the quality of your sources it is therefore important when referencing journal or conference papers to highlight the name of the journal or conference. Providing the web address where you obtained the paper can be a distraction and this detail can be safely ignored.

1.12 How to Write a Research Paper

We started this chapter by refuting the myth that research was searching for information. Writing an essay may involve searching for information and summarising this but this is not the same for writing a research paper.

Research involves:-

- developing a hypothesis i.e. a new theory that can be tested
- doing experiments to determine whether or not the theory is valid
- drawing conclusions from the results,
- writing all of this up as a research paper and finally
- either presenting this research at a conference and getting the research published in the conference proceedings or
- publishing the paper in a journal.

Having now looked at the basics of research and the basic differences between research papers and books we can now consider what you need to do if you are to write a research paper.

Activity 18

Given what we have learnt about research answer the following questions (yes or no):-

a. In writing a research paper would you be expected to push forward the boundaries of human knowledge?
b. Is it good enough to read and summarise good quality research papers?
c. Are you expected to develop your own hypothesis?
d. Are you required to do your own experiments and report the results?

Feedback 18

The answer to these questions are:-

a. Yes you would be expected to make your own contribution to knowledge.
b. No, it is not enough to summarise good quality research papers
c. You would not start by developing a hypothesis…though you may develop one in the end. We will come back to this later.
d. No you would not be expected to do your own experiments.

If you are not expected to do your own experiments to test a hypothesis a key question is 'How else can you make a contribution to knowledge?'

Most research papers describe primary research – this is where the researcher has performed their own experiments – but there is another type of research paper called a survey paper.

In a survey paper the researcher does not do their own research. Instead the researcher surveys the research literature. In doing this they are still expected to a make contribution to knowledge by analysing the information they find and by reaching conclusions based on this analysis. This analysis may lead the researcher to propose a new hypothesis that then needs to be tested by further research.

When a student at University is asked to write a research paper they are almost always being asked to write a survey paper.

Giving you the skills to analyse research papers and write a good survey paper, that makes a real contribution to knowledge, is the goal of this book and each aspect of this task will be covered in detail later. For now a summary of the main steps is provided:-

1.12.1 Step 1) Determine the Question

Firstly you must decide what your research paper will be about. Doing this is not simple.

If you are to push forward the boundaries of knowledge you must know where one of the boundaries lies.

Gaps in our knowledge are reported in research papers thus to determine the question i.e. the topic of your paper. You will therefore need the skills to find a set of research papers on one coherent subject. Reading these will help you to determine the thrust of your paper.

Thus you cannot start the process by defining the topic of your paper as you must first identify the gaps in our knowledge.

You start by defining the general subject, find papers on this subject and use these to find the gaps in our knowledge. Based on these you define the precise topic of your paper.

We will cover the skills to do this later in this book.

Having determined the subject matter you will analyse the papers to generate new knowledge by…evaluation…comparison…application (see steps 2–4 below).

Finally you will need to write your research paper (step 5 below).

1.12.2 Step 2) Critically Evaluating the Research

Activity 19

Remember our simplified research method:- a) observe a phenomenon b) generate a hypothesis and c) test the hypothesis.

Consider the following description of some research and the conclusion reached and ask:-

a. Would you accept the conclusion as valid?
b. If not, why would you not accept this?
c. Is this based on your personal opinion or was there a flaw in the research?

One night after going out with some friends I noticed that many of the people I met seemed to support the local football team and virtually no one was supporting a different team – many of the people I met were wearing replica football kits and were celebrating a game won (sadly an event that is unusual ☹).

From this I developed the hypothesis 'My local football team is the most popular team in the world' – a legitimate testable hypothesis.

To test this I developed a simple questionnaire, with just one question on it, 'Which is your favourite football team?'

Being a good researcher I made sure that my questionnaire did not asked biased questions, such as 'Is the local football team your favourite?' and knowing it was important to base my results of a sample that was not too small I went into the city centre and asked 500 people to answer my short questionnaire. As I also knew it is important not to bias the results I made sure the people who answered the questionnaire were strangers who passed at random and were not selected by me.

In response to this questionnaire some people did say that they did not like football but when pushed they did say they liked it when the local team won as this made other people around them happy.

The final results from the survey were are follows:-

87% supported the local football team
10% supported other teams
3% denied supporting any team (even when pushed to give an answer).

From this I concluded my hypothesis was indeed correct – my local team is the most popular team in the world and the result was not even marginal.

So:-

a. Do you accept the conclusion as valid?
b. If not, why would you not accept this?
c. Is your answer to (b) based on your personal opinion or can you find a flaw in my research?

Feedback 19

I am sure that you do not accept the conclusion as valid and if not this should not be because of your personal experience or personal opinion but should come from critically evaluating the research.

There were two significant flaws with this research as I am sure you noticed:-

1. The respondents were not people taken at random – they were all walking down a street in the local city. Thus they probably lived or worked in the area and therefore were more likely to support the local team than any other. The respondents were certainly not representative of people from around the world.
2. The questionnaire was indeed unbiased but by the time I pushed the respondents 'who didn't like football' the results certainly were biased.
3. You could question whether the sample size was large enough but actually it was quite large and the results were not marginal – asking more people would not likely have made any difference.

The example of research described above is simplistic and deliberately flawed. The purpose was to show that by critically evaluating the research you can reach your own conclusions. You can conclude that the researcher's conclusions are flawed or you can conclude that the researcher's conclusions seem to be justified. Either way your conclusion should be based on a judgment of the research process and evidence used to support the researcher's conclusions.

Critical evaluation does not mean finding fault.

'Critical' in this context means 'Very Important' – it does not mean criticise.

Critical evaluation therefore means to judge the important aspects of the work.

If we evaluate the research and find no flaws then we have reason to accept the conclusions are valid i.e. the research has value.

Activity 20

Another common flaw researchers often make is to assume that a causal relationship exists just because there is a relationship between two events. A causal relationship means that one event has caused the other.

Consider the following scenario:-

I believe I am extremely popular (people do occasionally laugh at my jokes even if my daughter doesn't) – that is my hypothesis.

To test this I watch what happens when I get off the train at the centre of my city (the last stop on the line) and I notice that when I get off everyone else gets off as well.

Is there really a causal relationship here? By this I mean am I really so popular that my departure causes everyone else to leave the train at the same time?

Feedback 20

Of course the events are related. I get off the train because the train has arrived at the city centre – everyone else gets off the train at the same time for the same reason.

This does not mean to say my departure has caused everyone else to leave the train.

If I reached this conclusion it would be a mistake.

It is easy to make a mistake when doing research by incorrectly assuming a causal relationship exists.

Identifying a relationship between two events does not mean to say that one has caused the other. Take a classic example:- if you notice that smokers have a higher incidence of cancer does that mean that smoking has caused the cancer…or could it be that the smokers are smoking to distract themselves from their worries?

Did the smoking cause the cancer or did the cancer cause the smoking? Or indeed are the patients with cancer just smoking a lot because someone nearby a cancer hospital is selling cigarettes very cheaply?

If we incorrectly assume a causal relationship exists between smoking and cancer then we are wasting lots of time, money and effort to reduce smoking as this won't save lives.

Of course we know that smoking does cause cancer and reducing smoking will reduce the incidence of cancer but the point remains valid – just because two events have a relationship does not mean we can assume that the relationship is a causal relationship.

When researchers reach conclusions we must critically evaluate the evidence to see if their conclusions are sound and this evaluation should not be based on your personal experience or opinion but on sound well-reasoned arguments.

By critically evaluating research we can make a contribution to knowledge by confirming or casting doubt upon the claims for knowledge that other researchers make.

Critical evaluation requires:-

a) an evaluation of research methods,
b) evaluating the discussion of results, and
c) evaluating the conclusions reached.

All of this requires a deeper understanding of:-

- research theory,
- how research should be conducted and
- the importance of experiments and experimental design.

These topics will be discussed later in this book and will enable us to consider what, if anything has gone wrong with the research.

1.12.3 Step 3) Comparing Different Theories or Methods

Having evaluated research the next step is to compare different theories or methods.

Different researchers, in different papers, will propose different theories or different ways of solving the same problem.

You may be the only person who has read a particular combination of papers therefore you may be the only person in the world who is in a position to compare and contrast these different theories or methods.

Activity 21

Consider the following two cameras (other cameras, by other manufacturers do exist):-

Sony DSCHX50 a compact 20 MP digital camera with a 30X optical zoom. A small light camera designed for travel and convenience that takes reasonably good photographs.

Sony Alpha 77 mark II a 24 MP entry level professional camera which requires a range of lenses and is a bulkier camera but produces excellent images.

The description above is not designed to endorse particular products and the accuracy of it is not confirmed – the description above is purely for the purpose of this exercise.

Consider what conclusions or proposals could you reach if you were able to really compare these cameras in depth – not just by comparing the simple descriptions provided but by also comparing the internal working and the designs of the cameras.

Feedback 21

Clearly we could compare the cost of the cameras, the resolution, details of the image sensor in each camera and details of the image quality (as evidenced by benchmark tests) and reach conclusions regarding the relative cost v's quality of the camera to determine if the more expensive camera is really that much better. If everything else was similar we could perhaps also make deductions about the relative quality and impact of the differing image sensor.

Finally if we really thought about it deeply we could perhaps think about how a hybrid camera could be designed, such as the Sony HX400V, which may have some of the advantages of both – higher image quality but without the hassle of having to carry multiple lenses. Then again this may have some disadvantages…not as small and convenient as the DSCHX50 but having a smaller sensor than the Alpha 77 mark II and thus a compromise in terms of quality.

…sadly the HX400V has already been thought about and designed so we can't claim the credit.

Just as comparing the cameras is not a simple task comparing different theories or methods is not simple. It takes thought and a reasonable knowledge and understanding of the detail and differences between the proposed methods…but by doing this comparison you can again push forward the boundaries of human knowledge by proposing potential improvements.

Remember you may be the only person who is in a position to compare the methods having been the only person to read two particular research papers.

Your comparison may show that one method is always more accurate than another and therefore you may be able to recommend that one of the methods is discarded in favour of the other. By comparing in detail how different methods work you may be able to propose a hybrid method by combining parts of each – but which parts would be combined and how? Would the hybrid method give you the advantages of both methods to overcome the disadvantages, would it combine the disadvantages or would it do both?

By comparing current theories and proposing a new theory, or by proposing a new method, you are effectively proposing a new hypothesis…ie that your proposal is better than the alternatives. Of course this may then require experiments to confirm your hypothesis and you can propose the experiments that would test your proposed theory or method…but even without doing this experiment your comparison has hopefully led to a new proposal that will help to push forward the boundaries of human knowledge.

1.12.4 Step 4) Applying the Theories or Methods

Activity 22

Consider the same two cameras:–

Sony DSCHX50 a compact 20 MP digital camera with a 30X optical zoom. A small light camera designed for travel and convenience that takes reasonably good photographs.

Sony Alpha 77 mark II a 24 MP entry level professional camera which requires a range of lenses and is a bulkier camera but produces excellent images.

Which of these would you recommend to someone hoping to start a business as a professional wedding photographer?

Which would you recommend to a professional photographer wishing to win an international photography competition for professionals where the goal is to photograph microscopic life?

Feedback 22

Thinking about this it is of course easy to recommend the Sony Alpha 77 mark II to a professional wedding photographer but is this camera really good enough when wishing to photograph microscopic life? If not, why not? What features would a camera need for this application? What recommendations could you make?

The final way in which you can make a real contribution to knowledge is to consider how the theories or methods apply to a range of real life situations…or indeed will the theories/methods fail under certain conditions?

You may be able to consider situations that the original researchers failed to consider and thus you may make valuable recommendations that enables the research to be used to solve real world problems.

Thus by a) critically evaluating the research, b) comparing the theories and c) considering the application of the theory your aim is to present your conclusions…and in each case your conclusions should be backed up by well-reasoned arguments – not by personal opinion.

By doing all of this you will be able to write a research paper that makes your own unique contribution to knowledge!

Presenting your analysis requires you to do far more than just present a summary of current research papers. It is by doing this analysis that you make a contribution to knowledge and it is your contribution that makes your paper worth reading.

1.12.5 Step 5) Write your Research Paper

The final task involves writing your research paper:-

- writing an engaging abstract,
- writing a focussed introduction,
- writing a clear summary of current research,
- presenting your analysis and reasoned argument (your evaluation, your comparison and your consideration of the application of the theory)
- bringing together your conclusions and leaving the reader feeling that you have made a clear contribution to knowledge.

In reality this task cannot be done at the end – your paper will need to be drafted and refined. Drafting your paper will help you to define the question and the title of the paper itself may evolve. Certainly the arguments you make and the body of the paper will need to evolve and be refined as you progress.

None of this is easy of course. All of this involves advanced academic skills that I hope to help you develop through the exercises and feedback in the following chapters of this book.

A final point to remember:- as challenging and as daunting as this task is, others, who had no knowledge of research at the start, have managed this before you. **If they can do this so can you!**

1.13 Summary

To summarise this chapter…research is not about finding information. Research is a process by which the boundaries of human knowledge are pushed forward. This involves developing a hypothesis, testing the hypothesis and reaching conclusions based on this testing.

We will be judged on the quality of the sources we use and therefore we must use and correctly reference journal and conference papers.

The research process requires accurate data and has many potential errors hence why we need to critical evaluate the evidence.

As we are evaluating the research done by others,
others will evaluate the quality of our analysis.

Therefore the conclusions we reach should be based on well-reasoned argument not personal opinion or bias.

Finally by critically evaluating the evidence, comparing the theories and by considering how the theory may apply to real world situations we can reach our own well-justified conclusions and these conclusions are our contribution to knowledge.

We will return to each of the concepts introduced here throughout the book and hopefully, by the end, you will have a good understanding of these concepts and understand how to apply them.

Please note: Many of the activities in this book require research papers and videos to be accessed via links to the web. If any of these materials have moved and the links broken please use the relevant keywords and Google to find current versions of the materials.

2 Research – Changing our World

Introduction

Research is an active task that pushes forward the boundaries of knowledge. It is done by passionate, intelligent people who want to make a positive impact on our changing world.

Research is not done by people with strangely shaped heads wearing smelly lab coats – OK they sometimes do wear smelly lab coats.

This chapter will highlight samples of research and the impact this could have on our world over the next 5–10 years.

Any research paper you write must make your contribution to this changing world. This chapter may help you to appreciate some of the possibilities.

Objectives

By the end of this chapter you will be able to…

- Understand the impact research could have on our world in the near future,
- Understand some of the human stories and passion that drives the innovation forward.

This chapter consists of 17 sections:-

1. Researchers Change the World
2. Astronomy Research
3. Business Research
4. Computing Research
5. Construction Research
6. Engineering Research
7. Environmental Research
8. Humanities Research
9. Medical Research
10. Military Research
11. Psychology Research
12. Science Research (Physics, Chemistry, Biology and Mathematics)
13. Robotics Research
14. Space, Aircraft and Automotive Research
15. Sports Research
16. Technology Research
17. Your Contribution to a Changing World

2.1 Researchers Change the World

When you write a research paper you should make a contribution to knowledge that may have an impact on one aspect of a changing world.

Activity 1

Listed in this chapter are a collection of short videos that highlight practical examples of current research. The passion of the researchers and the impact this research could have on changing our world is evident in many of these videos.

The list of subjects is not comprehensive and certainly it would be impossible to give you an up-to-date comprehensive list of research projects.

Watch whichever videos are of interest to you – I would encourage you to watch them all – and while doing so think about the researchers, who are intelligent passionate human beings, and their vision for a changing world.

There is no feedback for this activity but the final section of this chapter includes a task for you to do which the videos may help with.

As mentioned above you don't need to watch all of the videos and you can skip complete sections if you wish, but don't skip the final section of this chapter.

2.2 Astronomy Research

2.2.1 Search for Extra-terrestrial Intelligence SETI (3 minutes).

https://www.youtube.com/watch?v=lp67zdDDA9M

2.2.2 Professor McAteer describes the study of Space Weather (3 minutes).

https://www.youtube.com/watch?v=FPNPnCw2MsQ

2.2.3 Large Hadron Collider at CERN Testing the Origins of Dark Matter (3 minutes).

https://www.youtube.com/watch?v=tqY7V2v51hQ

2.2.4 Astronomers have discovered a ring system of enormous proportions, much larger and heavier than the ring system of Saturn (2 minutes).

https://www.youtube.com/watch?v=a-0SHPiUhJ0

2.3 Business Research

2.3.1 Professor Miller discusses research being done to make tourism destinations more sustainable and competitive and develop a system of tourism indicators (2 minutes).

http://www.youtube.com/watch?v=VrYtXDqySrE

2.3.2 Professor Dibben discusses research being done to support vulnerable workers (1 minute).

http://www.youtube.com/watch?v=BssrS3RCSjk

2.3.3 Professor Robinson discusses research being done to improve the way institutions are managed in a responsible way (1 minute).

http://www.youtube.com/watch?v=sWLyQChCufM

2.3.4 Professor Romero-Morales discusses research being done to help businesses manage big data to make more informed decisions and improve customer satisfaction (4 minutes).

http://www.youtube.com/watch?v=Yq8zECeUTMY

2.3.5 Professor Radnor discusses research being done to help public services become lean, sustainable and cope with cuts in funding (3 minutes).

http://www.youtube.com/watch?v=NOLkoAG0C00

2.3.6 Professor Rothaermel discusses research on how firms learn new things, adapt and embrace change such as the digital revolution (1 minute).

http://www.youtube.com/watch?v=ht35setkxzU

2.3.7 Professor Yamamoto discusses research being done to design systems for the labour market that take into account work-life balance, mental health and business performance (5 minutes).

http://www.youtube.com/watch?v=Fli6AcxbbkM

2.4 Computing Research

2.4.1 Professor Warwick, *the world's first human cyborg*, discusses the impact cybernetic research can have on patients with dementia or patients who are paralysed (7 minutes).

https://www.youtube.com/watch?v=YbBMLN_kVnM

2.4.2 Staff from IBM research discuss 'Watson' a computer with stunning levels of human like intelligence (6 mins).

https://www.youtube.com/watch?v=ZvDyE9Guwls

2.4.3 Staff from IBM research celebrate the product of 4 years of research when 'Watson' beat the two greatest Jeopardy champions of all time and consider the impact this will have on the future (10 mins).

https://www.youtube.com/watch?v=lI-M7O_bRNg

2.4.4 Forward Thinking discusses research being done allow people to control computers with their minds (4 minutes).

https://www.youtube.com/watch?v=Fxn6kXNLkAE&list=PLcuqCOJCLvds1fo9IWyu61uAlT8xf4Fwh&index=65

2.4.5 Staff from the Ubiquitous Computing (UbiComp) research lab, led by Professor Patel, discuss health sensing research that aims to improve the quality of health care (2 mins).

https://www.youtube.com/watch?v=Dq3EYjyAAec

2.4.6 Professor Bethel discusses research being done to improve human-robotic interaction to help humans in risky law enforcement situations (4 minutes).

https://www.youtube.com/watch?v=MT0xgxj2rm4

2.4.7 In today's world security is a critical subject and Dr Foo discusses research to enhance the security of industrial control systems by protecting them against cyber attacks (2 minutes).

https://www.youtube.com/watch?v=5X3reWHabXc

2.4.8 Dr. Cheung discusses research that aims to ensure online security without compromising privacy (3 minutes).

http://www.youtube.com/watch?v=1r5C6YF5WKU

2.4.9 Data centres use huge amounts of energy and with the advent of the cloud are becoming more and more common. Professor Mars discusses research in the architectural design of data centres to improve efficiency (3 minutes).

http://www.youtube.com/watch?v=qS-Dyb_uvcs

2.4.10 Researchers combine virtual reality with gesture control devices to make more immersive gaming environments (2 minutes).

http://www.youtube.com/watch?v=hIP1kNsi-Go

2.5 Construction Research

2.5.1 Professor Cooper, Dr Paine and Dr Sharma discuss the use of bacteria to make self-healing concrete (4 minutes).

https://www.youtube.com/watch?v=9q1elXcL0GA

2.5.2 Dr Buswell, Professor Austin and other scientists explore 3D Concrete Printing the Future of Construction (3 minutes)

https://www.youtube.com/watch?v=u0vATVp4nlQ

2.5.3 Professor Xiangyu Wang explores the use of Augmented Reality to Improve Productivity in LNG Construction (2 minutes).

https://www.youtube.com/watch?v=rdUIjGlVBY8

2.5.4 A mechanical engineering professor proposes steps to help reduce tornado damage (2 minutes)

https://www.youtube.com/watch?v=tVMAiHuzYy4

2.5.5 Associate Professor Kamat and other researchers explore the use of augmented reality to improve construction safety (3 minutes).

https://www.youtube.com/watch?v=i1fBiFSwoX4

2.6 Engineering Research

2.6.1 Professor Lin and her team discuss research to produce a more efficient method for making bio fuels or other chemicals (3 minutes).

http://www.youtube.com/watch?v=faA-jT3T0nw

2.6.2 Professor Karnik discuss research in nanoscale fluid engineering that could produce extremely cheap drinking water which and could save a million lives each year (4 minutes).

http://www.youtube.com/watch?v=gW01fPVKciY

2.6.3 Professor Naito helps re-create tsunami debris impacts to establish new design standards and building codes in the hope that, in the future, tsunamis will be less destructive (3 minutes).

http://www.youtube.com/watch?v=kpu-mUf5A_A2.6.4

2.6.4 Associate Professor Chandran discusses research in environmental engineering which aims to produce sustainable ways to address water, sanitation and human health (2 minutes).

http://www.youtube.com/watch?v=2TfBmTOZd8s

2.6.5 Professor Petrenko discusses research on ice control which aims to make safer vehicles (2 minutes).

http://www.youtube.com/watch?v=yGjWN6Ay5s8

2.6.6 Professor Lee discusses research in nanoscale engineering to produce new computer processor technologies (2 minutes).

http://www.youtube.com/watch?v=gr85i86jTT8

2.7 Environmental Research

2.7.1 Professor Richard Muller a global warming sceptic undertakes research to try and prove that climate change is a hoax (5 minutes).

http://www.youtube.com/watch?v=a6FbISa3nFQ

2.7.2 Microbial oceanographer Associate Professor Dyhrman discusses her research which focuses on microbes in the ocean influencing the earth's climate (4 minutes).

http://www.youtube.com/watch?v=8LvVn6iLaPs

2.7.3 Research shows climate change affecting species distribution (2 minutes).

http://www.youtube.com/watch?v=n81Pwweb62Y

2.7.4 Researchers use flying lab to study the atmosphere and develop prediction models for severe weather events to save lives (3 minutes).

http://www.youtube.com/watch?v=z9UYCyBBc9Q

2.7.5 Professor Alam and his team discuss renewable energy research which aims to convert ocean wave power into useable energy (3 minutes).

http://www.youtube.com/watch?v=gZFM0ghuwZs

2.7.6 Dr Strandmann describes research that uses fossil evidence to understand the potential impact of global warming (2 minutes).

http://www.youtube.com/watch?v=N0BzG8FlFWs

2.7.7 Dr. O'Keefe, an Associate Professor, and Julie Meachen an assistant professor discuss research that shows the link between climate warming and the evolution of Ice Age predators (3 minutes).

http://www.youtube.com/watch?v=jK_DKSNbgR4

2.8 Humanities Research

2.8.1 Professor Laurie discusses research being done to help understand society and how family's lives change (3 minutes)

http://www.youtube.com/watch?v=y3IXprSddNc

2.8.2 Professor Slater tests virtual reality as a mechanism to tackle racism and implicit human bias (3 minutes).

http://www.youtube.com/watch?v=E56kyAXnuzg

2.8.3 Professor Gentzkow discusses research on the impact of the internet on human beliefs (1 minute).

http://www.youtube.com/watch?v=K9vncgaabJ0

2.8.4 Professor Warren discusses virtual reality crowd behaviour modelling to understand the behaviour of individuals within the crowd (1 minute).

https://www.youtube.com/watch?v=qRygOPmcHDQ

2.8.5 Dr Garvey discusses a seven-year project to find out more about the indigenous Australian communities who lived more than 15,000 years ago (3 minutes).

http://www.youtube.com/watch?v=9nZeWKVNzjA

2.9 Medical Research

2.9.1 An enthusiastic and passionate multidisciplinary team explain the mitochondrial disease research they are doing the impact this could have on human aging, genetic and neurological disorders and improve patient care (7 minutes).

http://www.youtube.com/watch?v=YrNEHsHtZF4&feature=youtu.be

2.9.2 Genome research, that will revolutionise medicine, is described (3 minutes).

http://www.youtube.com/watch?v=5AEcHSYnfjc&feature=youtu.be

2.9.3 Dr Goldstein discusses stem cells research, making the impossible possible (16 minutes).

https://www.youtube.com/watch?v=tplx_ftKdYc

2.9.4 A patient's family discuss their involvement in a research project and explain the importance of this for them and their daughter (4 minutes).

http://youtu.be/Deo3YM8i5c0

2.9.5 Farzana Rahman uses high performance computing to develop the next generation of medicines (3 minutes).

https://www.youtube.com/watch?v=XxjMiPQNfag

2.9.6 Dr. Parr discusses autism research and the use of virtual reality to treat patients (2 minutes).

https://www.youtube.com/watch?v=OReNxs5syyA

2.9.7 Various researchers discuss work on smart medicines and tiny nanobots, built from human DNA, to treat cancer (2 minutes).

https://www.youtube.com/watch?v=WNyELeIszxA

2.9.8 Pediatrician Dr. Jim Sears looks at 3D printing research and the impact this can have on medicine and surgery (3 minutes).

https://www.youtube.com/watch?v=DSWMqyv2pCQ

2.9.9 Human brain research aims to provide a better understanding of brain disease and personalised patient treatments (2 minutes).

https://www.youtube.com/watch?v=zI-x79ONMBs

2.10 Military Research

2.10.1 Dr. Glaz discusses research into carbon nanotubes to improve the structure of military helicopters (2 minutes).

http://www.youtube.com/watch?v=1XlMVL2w7RU

2.10.1 Dr Hall, materials engineer, discusses aerodynamic flow control research to improve efficiency and capabilities for military aircraft (2 minutes).

http://www.youtube.com/watch?v=m0Z5Tp67Fdg

2.10.2 US Navy unveils new futuristic weapon research which is ongoing (3 minutes).

http://www.youtube.com/watch?v=j6K1gjHNg38

2.10.3 Explanation of new US laser weapon technology (4 minutes).

http://www.youtube.com/watch?v=F79a0G_-mhg

2.10.4 Professor Alu describes research into invisibility technology (3 minutes).

http://www.youtube.com/watch?v=ScaxoyDIrqs

2.11 Psychology Research

2.11.1 Professor Farrington receives the 2013 Stockholm Prize in Criminology and discusses some of his research regarding the impact of bullying (4 minutes).

http://www.youtube.com/watch?v=5QD4fz_S_WQ

2.11.2 Professor Wood discusses some research on the impact of text messaging on children's understanding of grammar with surprising results (3 minutes).

http://www.youtube.com/watch?v=iL2vD-sVweM

2.11.3 Professor Easton, a professor of forensic clinical psychology, explains her research which aims to help patients with drug and behavioural problems (1 minute).

http://www.youtube.com/watch?v=b57Pq0BFV5k

2.11.4 Professor Freeman talks about research into the potential use of virtual reality as a treatment for paranoia (4 minutes).

http://www.youtube.com/watch?v=swFlXaGbaXQ

2.11.5 Neuroscientist Professor Huffman explains her research that shows how consumption of alcohol during pregnancy disrupts brain development (2 minutes).

http://www.youtube.com/watch?v=u9bvUKCZPOE

2.11.6 Assistant Professor of Psychology Hudenko discusses his research which focuses on laughter amongst Autistic children (3 minutes).

http://www.youtube.com/watch?v=D5okza8D0eA

2.11.7 Dr. Calfano explains some of his recent research on the effects of religion and gender in political engagement (3 minutes).

http://www.youtube.com/watch?v=iQ1YF8dBw_k

2.12 Science Research (Physics, Chemistry, Biology and Mathematics)

2.12.1 Maryam Mirzakhani, an Iranian-born mathematician has become the first woman ever to win the Fields Medal – the most prestigious honour widely viewed as the Nobel Prize of mathematics (2 minutes).

https://www.youtube.com/watch?v=8II_FPrrNKw

2.12.2 A research team is the first in the world to see atomic changes in proteins that could have huge implications for the future (2 minutes).

https://www.youtube.com/watch?v=uTSvEby-xqw

2.12.3 Sweden: Nobel Prize in Physics goes to a Japanese team for low-energy LED light (1 min).

https://www.youtube.com/watch?v=I0KmtarAJ34

2.12.4 Professor Freer discusses his research into nuclear physics (2 minutes).

https://www.youtube.com/watch?v=uN8VugYH-7A

2.12.5 Dr. Wright Discusses the Molecular Biology of Ovarian Cancer (1 minute).

https://www.youtube.com/watch?v=vc_fbJPQuKI

2.12.6 A Stanford Researcher Warns of Mass Extinction (3 minutes).

https://www.youtube.com/watch?v=cmb5hn2X2ok

2.12.7 Professor Badding leads a research team that has discovered how to produce super-strong, super-thin diamond nanothreads (1 minute).

https://www.youtube.com/watch?v=Ok-D9pn8C1g

2.12.8 Thomas Webster, Chair & Professor, Department of Chemical Engineering speaks about nano-technology (1 minute).

https://www.youtube.com/watch?v=uxRzBXbLm9M

2.13 Robotics Research

2.13.1 Science fiction is coming true: Honda Research & Development display Asimo the world leading humanoid robot that demonstrates advanced artificial intelligence and human like senses (7 minutes).

https://www.youtube.com/watch?v=JlRPICfnmhw

2.13.2 Professor Rus discusses the development of soft bodied robots that allows very agile manoeuvres (3 minutes).

http://www.youtube.com/watch?v=BSA_zb1ajes

2.13.3 Forward Thinking discusses the potential for robotic surgeons (5 minutes).

https://www.youtube.com/watch?v=vb79-_hGLkc

2.13.4 Professor Velonaki and Professor Matsumoto discusses research investigating methods to encourage sociable robotic human interaction (2 minutes).

http://www.youtube.com/watch?v=9Hn9Z9PrSt8

2.14 Space, Aircraft and Automotive Research

2.14.1 NASA considers the research needed for deep space exploration and to land a human on Mars (5 minutes).

http://www.youtube.com/watch?v=noEod29Tr6c

2.14.2 Spacecraft rendezvous with comet, a technological and human first, in order to research the origins of solar system (2 minutes).

http://youtu.be/8673j_YQvhk

2.14.3 Meteorite research reveals secrets of Mars' past (3 minutes).

http://www.youtube.com/watch?v=8OMg7-uG1Q0

2.14.4 Professor Kimura discusses research which aims to reduce space debris (1 minute).

http://www.youtube.com/watch?v=VDe8UqRdnVE

2.14.5 Professor Atkins discusses research in unmanned aircraft, teaching them how to handle anomalies and become safer (3 minutes).

http://www.youtube.com/watch?v=UMFd4Blkjtc

2.14.6 Professor Wheeler discusses research into aircraft electronics to make the aircraft more environmentally friendly (3 minutes).

http://www.youtube.com/watch?v=AZd-KMu7PNQ

2.14.7 NASA Dryden staff discuss research into sonic booms in order to create supersonic airplanes that are quiet and can fly over populated areas (2 minutes)

http://www.youtube.com/watch?v=iPvo7h6fum0

2.14.8 Mark Musculus, an engine combustion scientist, discusses research to build cleaner, more efficient engines (2 minutes).

http://www.youtube.com/watch?v=FbPHdDJbxGg

2.14.9 Dr. Abu-Farha discusses research designed to minimize the weight of vehicles to improve fuel economy and reduce emissions (1 minute).

http://www.youtube.com/watch?v=ADxLOU6owME

2.14.10 Staff at Stanford discuss a new simulator that allows flexible experiments to test interface design, eye tracking and brain activity (3 minutes).

http://www.youtube.com/watch?v=PunW-Ptrkk4

2.15 Sports Research

2.15.1 Professor McPhee discusses research that aims improve athletic performance through a deeper understanding of biomechanics, mechatronics training devices and athletic equipment (1 minute).

http://www.youtube.com/watch?v=Vl2XOKsHxwo

2.15.2 Warren Dunn, Orthopaedic surgeon, talks about the importance of sports medicine research (2 minutes).

http://www.youtube.com/watch?v=XlYu5hgGuqg

2.15.3 Dr Didymus discusses research that aims to provide effective coping strategies for stress in sport (3 minutes).

http://www.youtube.com/watch?v=tz79iu8-lVc

2.16 Technology Research

2.16.1 Professor Cheok discusses research to enable touch communication through the internet (2 minutes).

http://www.youtube.com/watch?v=JWtBj8TWFLc

2.16.2 Professor Monks describes his research in forensic science to detect the smell of crimes (3 minutes).

http://www.youtube.com/watch?v=ebq15BosLHk

2.16.3 Facebook's Yael Maguire talks about research into new technologies to improve internet connectivity for communities around the world (4 minutes).

http://www.youtube.com/watch?v=pxX6r-xDgG4

2.16.4 Forward thinking discusses the possibility of flying cars (4 minutes).

http://www.youtube.com/watch?v=CKYS0xHtelo

2.17 Your Contribution to a Changing World

Hopefully you will now appreciate some of the contributions scientists and researchers are trying to make to the world in which you live.

There is one thing all these researchers share…a passion for their subject.

Activity 2

Spend a few minutes considering your subject area…

What problems still need to be solved?
What can the specialists in your field still not do?
What do they still not know?

What contribution could you potentially make if you became a scientist or researcher?

Feedback 2

If you are required to write a research paper the topic of the paper may be specified. In this case you will with any luck be able to see it is relevant to the degree you are doing.

However if you have a choice in the subject then finding a subject area that is of interest to you will make the task of writing the paper much nicer.

Hopefully the videos above will have helped to inspire you to pick a subject that a) is of interest to you and b) one where you can make a real contribution.

In the next chapter we will start developing the practical skills you need in order to write a research paper. Specifically:-

a) how you can choose an appropriate topic for your paper,
b) how you decide on the specific title for your paper and
c) how you find research papers appropriate for your paper.

3 Finding Research Papers

Introduction

This chapter will start to help you develop the practical skills you need in order to write your research paper.

So far we have looked at the basic principles of research – that the purpose is to push forward the boundaries of human knowledge – and we have looked at some of the work being done by researchers in a range of different subjects.

We have discussed the definition of knowledge – true justified belief – and the role that experiments play to verify a hypothesis.

We have also discussed briefly how, when writing a survey paper you can make a contribution to knowledge, i.e. by critical evaluation, comparison and application of theory, even though when writing a survey paper you won't be reporting your own experiments.

In discussing this we also looked at one critical role of a research paper – so researchers can publish their research results and conclusions. However research papers do have another role…they exist so other researchers, such as yourself, can discuss and critically evaluate the research reported in the papers.

Other researchers expect you to critically evaluate their work. They welcome this as they recognise the role you can play to push forward the boundaries of human knowledge.

In order to do this there are several important skills to develop. The first is to learn how to find research papers…but not just any research papers. You need to find a group of papers that are appropriate for your research paper title. This is the main skill we will develop in this chapter.

Assuming you have a choice of topic, you will also need to develop an appropriate title for your research paper. To do this you will need to understand what makes an appropriate title. In this chapter we will also consider what makes an appropriate title for your research paper.

Objectives

By the end of this chapter you will be able to…

- use two tools to find research papers,
- develop your searching skills,
- find a cohesive set of good quality research papers appropriate for your paper.
- understand what makes an appropriate title for a research paper or research chapter and, just as importantly,
- what makes an inappropriate title and why.

In later chapters we will learn how to analyse these papers and learn how to write your own but for now it is important that we learn how to find the papers we will use.

Remember you will be judged on the quality of the sources you use so you will learn specifically how to find a set of journal and conference papers, i.e. good quality research papers, appropriate to the paper you will write.

This chapter consists of 9 sections:-

1) An Unexpected Starting Point
2) Choosing a General Topic for your Research Paper
3) Tools for Finding Research Papers
4) Learning How to Find Research Papers
5) How to Find a Coherent Set of Research Papers
6) Choosing a Title for Your Research Paper
7) Choosing a Title for a Dissertation Research Chapter
8) Other Resource Discovery Services such as the Directory of Open Access Journals (DOAJ)
9) Summary

3.1 An Unexpected Starting Point

Activity 1

Consider any essay you have ever written. Did you start with a topic and then find appropriate books and resources? Or did you wander through the library, looking at all of the 1000's of books available, and think what should I write my essay on?

Now consider the following question:-

Assuming you are free to choose the topic of your research paper…

a. Should you start be defining the topic/title of your paper and then find appropriate research papers for this given topic?
b. Or should you find the research papers and then define the title of your paper based on the research papers you find?

If you choose option b, and you therefore do not know the topic, how do you decide which research papers you will use?

Feedback 1

It seems self-evident that you must first define the topic and then, knowing what the topic is, you can find appropriate research papers. However writing a research paper and writing an essay are quite different tasks and this approach will not usually work well for reasons explained below.

Activity 2

Consider you are planning an extremely unusual trip…you have never seen the Sahara desert and you want to see what it is like there:-

a. Should you start by deciding exactly where within thus huge desert you want to visit and then get the appropriate maps?
b. Or should you get the maps first and then use these to decide where best to visit?

Feedback 2

Clearly if there is a specific place you want to visit then you need to work out how to get to that specific place but sometimes it is best not to start out with a firmly fixed idea of your destination but to let your destination be dictated by pragmatic concerns e.g. convenient travel options. You can still explore and enjoy the results.

In a similar way when writing a research paper you may suppose that you should start by defining your research topic and the title of your paper and then find appropriate research papers given the title of your paper. However this approach can lead to very specific problems:-

> What if no one is doing research on your chosen topic because it is too difficult (e.g. time travel)?
>
> What if the research in this area was all done years ago and researchers have now moved on to newer topics (e.g. 'transputers'…a computing research topic that was hot the 1990s but is now no longer a current topic).

Remember research is about pushing forward to boundaries of human knowledge. **If you don't know where these boundaries are you cannot decide on an appropriate topic!**

There is one place where you can find out about the current limitations in our knowledge, i.e. where the boundaries are, and that is in research papers.

Research papers finish with conclusions that describe what has been learnt from the research but also they often describe what problems still need to be solved. These problems are the boundaries…things we still need to learn.

Research papers will also often describe competing theories proposed by different researchers…thus they describe things that we are still not certain of i.e. which method or theory is best.

Thus research papers show us areas of uncertainly…i.e. they show us what would make a good topic for further research and for our research papers.

Thus instead of first defining the title of your paper and then finding appropriate research papers you must first find research papers and use these to define the title of your paper. However as there are tens of thousands of recent research papers we can't look at all of these to determine appropriate research so we must have a starting point, i.e. a topic of interest to us.

Therefore to find appropriate research papers for the paper you are writing you should follow the following process:-

1) Determine a research topic that is of interest to you.
2) Find a few research papers on one focussed sub-topic within this general topic (finding these research papers is evidence that researchers are working in this area – so you have found a valid topic).
3) Use these papers to define the title for your research paper.
4) Find as many additional research papers for your paper as you require.

We have therefore an unusual starting point…we must find research papers ***before*** we define the title of our research paper.

Finding these papers will show that our paper is on an appropriate topic because a) it is looking at one boundary of human knowledge b) the topic is current and researchers are working on this problem.

Of course the topic of your paper may be previously defined because you are doing a precisely specified assignment. In this case you do not need to be concerned whether the topic is appropriate or not and you can therefore start with step 4 above. You will still need to learn how to find a cohesive set of papers on this topic and hopefully this chapter will help you with this.

3.2 Choosing a General Topic for your Research Paper

Assuming you can specify the title of your research paper you must somehow start by defining the general subject area or topic of interest. This will help to narrow the starting point for your initial literature search…though this is only a starting point and we may change our focus as we search for papers.

Appendix 2, at the end of this book, contains a list of general subjects. Within each of these general subjects is a list of narrower subject areas that researchers are working in.

If you have a choice of topic then you can look at these subject areas and pick a subject that is of interest to you.

Under each of these topics are some suggested key words that you can use when searching for research papers though you can also make up your own search terms by either using words from the subject titles or from the short descriptions provided.

For example one sub topic within 'Computing' is 'Artificial Intelligence' and one of the search terms listed in appendix 2 within this is 'Vision Recognition' You can start your search using this search term or make up your own alternatives e.g. robotic vision, computer visions systems, neural networks for computer vision etc.

Of course the list of topics is not comprehensive and may not cover specific subjects you are interested in but hopefully it will give you some ideas for potential research papers.

The list of sub topics and search terms is certainly not comprehensive and you may need to consider your own starting point.

Activity 3

Consider the following book:-

Economics for Students and Non-Students Alike by Jerry Wyant, 2013.

It contains chapters on market structures, market failures, economic systems, and the business cycle, unemployment and inflation.

Within the chapter on market failures it may discuss stock market crashes. Within the chapter on the business cycles it may discuss functions in currency values e.g. the ratio between the values of the pound sterling and the American dollar etc.

Within the subject of economics there are lots of things that are well known and lots of things that we do not fully understand i.e. areas on which we could write a research paper.

Given this consider the following potential subjects for research and decide which of these would make the most appropriate topic for a research paper:-

a. Economics
b. Business Cycles
c. Currency Fluctuations
d. The Impact of Quantitative Easing
e. Using new computing techniques, e.g. Neural Networks, to improve prediction accuracy of currency values.

Feedback 3

The purpose of this exercise is not really to worry about what makes and appropriate topic for our research paper but to understand that research needs to be done on one very focussed subject and this has an impact when we start searching for research papers.

Topics (a)–(c) are too big and too unfocussed for one person to succeed at.

No one can research 'Economics' in general or indeed on 'Business Cycles' or 'Currency fluctuations'. These topics are far too wide and are made up of far too many unknowns to be the subject of one persons research.

Topic (d) 'The Impact of Quantitative Easing' is a much more focussed topic and could possibly be the subject of a significant research study, possibly leading to a PhD over three years, but even within this you will find it contains many smaller, more focussed, subject areas and thus is still probably too wide and too big for a single research paper.

A far more reasonable topic for an individual research paper could therefore be one focussed aspect of this, perhaps 'The Impact of Quantitative Easing on Currency Exchange Rates'.

Topic (e) 'Using Neural Networks, to improve prediction accuracy of currency values' is a very narrow topic and one that is far more likely to succeed as the subject of a research paper.

From the exercise above you may see that one essential feature for successful research is to ensure that the research has a very narrowly focused and clearly defined goal.

For now it is enough to note that you can do research on any subject that is of interest to you as long as this subject a) has a very narrow focus and b) is a subject that other researchers consider as current.

Books can help you choose a topic but don't look at the title of the book. Don't even consider the titles of chapters within the book but consider one topic within one chapter of a book.

Once you have narrowed your focus on one small subject area, e.g. 'currency values', then you can use terms from this topic to start your search process.

Activity 4

Take any text book you have.

Ignore any general introductory chapters and pick a chapter that seems to be generally focused on one subject area.

Scan the introduction to this chapter and look at the subsection headings. Try to find one on a clearly focussed topic.

Now look at this topic and pick out the key words that you think highlight what the topic is about.

Feedback 4

One of the books I own is about ethical issues in computing, one chapter of which is about things that can go wrong with software. Within this is a section on 'Safety-Critical applications' including air traffic control problems and radiation overdoses in medical computing devices.

From this I could pick any of the following potential terms when searching for research papers in computing: 'fly-by-wire systems', 'automated aircraft control', 'computerizing pilot functions', 'traffic collision avoidance systems' or on the medical side 'error message design'. 'medical software specifications' and 'errors in multitasking software'.

Of course there are also many other topics I could choose…all inspired by the same book.

Clearly we can follow this process using any textbook we like and pick any subject we like for our research…though we will need to confirm that other researchers are working in this area.

Picking one of these search terms is not the end it just gets us started when looking for research papers.

We will refine our search terms later and the papers we find will lead us to define a precise topic for our paper.

Given this it doesn't matter which terms we pick at the start and we can't get this wrong.

Having considered a starting point for our research, i.e. the search term we will start with, we will now consider:-

- What tools can we use to find research papers?
- How do we use these tools?
- and how do we refine our search terms to find a cohesive set of papers on a current and valid research topic?

3.3 Tools for Finding Research Papers

There are numerous potential tools you can use to help you find research papers. These tools are sometimes called 'Resource Discovery Services'.

Each of these tools has their own advantages but which you will use will often be determined by pragmatic considerations:- for example whatever tool your university subscribes to.

This chapter will introduce you to the EBSCO Discovery Service but will then focus on two tools that are free and available for your use:-

- IEEE Xplore
- Google Scholar

3.3.1 EBSCO Discovery Service

The EBSCO Discovery Service is a professional resource discovery service that provides sophisticated search tools and is an excellent resource for finding research papers. It can be branded by different institutions so it may not look the same in every institution that uses it but the features provided in those institutions are probably fairly similar.

When using this tool multiple online Databases are searched automatically and many research papers can be found and downloaded to your computer in minutes. You can search for papers on a particular topic or for papers with keywords in the title and you can sort the results by relevance or date i.e. those the computer thinks are most relevant to you or those that are most recent.

You can refine you search by limiting the search to 'Full Text' and 'Academic Journals':-

…and when the search is finished a list of retrieved papers will automatically be presented to you.

You can find out more details about the paper including the abstract and the source of the paper:-


meta-analysis of empirical evidence

Add to folder

Title: Does risk management contribute to IT project success? A meta-analysis of empirical evidence

Authors: Karel de Bakker,Albert Boonstra,Hans Wortmann

Source: International Journal of Project Management

Date: 2010

Publication Type: Academic Journal

Subjects: Managing risk,Project success,Information Technology

Abstract: The question whether risk management contributes to IT project success is considered relevant by people from both academic and practitioners' communities already for a long time. This paper presents a meta-analysis of the empirical evidence that either supports or opposes the claim that risk management contributes to IT project success. In addition, this paper also investigates the validity of the assumptions on which risk management is based. The analysis...

Database: ScienceDirect

Detailed Record

…and if your institution has access to that source then you can download a full copy of the paper immediately.

The system can also look at the full list of papers retrieved by your search and can intelligently categorise them into sub topics. You can then use this list to narrow down your search terms:-

If your institution has provided a particular resource discovery service, such as the EBSCO Discovery Service, then this maybe the best tool available to you but there are other options including:-.

- IEEE Xplore
- Google Scholar

3.3.2 IEEE Xplore

The Institute of Electrical and Electronics Engineers, commonly known as the IEEE, was founded as the American Institute of Electrical Engineers in 1884 but merged with another organisation and was renamed in 1963.

The IEEE is a very well respected professional institution that supports research conferences and prints journals on whole range of technological subjects including aerospace, communications and computing (both hardware and software).

Additionally other subjects are included that you may not consider as technology such as business, economics, criminology and sport.

While still technology oriented many of the subjects covered include human related aspects of technology such as human computer interfaces and medical diagnosis.

Using the IEEE search engine 'IEEE Xplore' you can gain access to over 3 million full text articles many of which are quality research papers published in journals or research conferences.

While most of the research papers are only accessible via a paid subscription, you may have access to these via a University library. Additionally some research papers are available for free and search results can be limited to these open access papers.

3.3.3 Google Scholar

Google Scholar is a free to use web based search engine. Unlike IEEE Xplore it is not limited to papers published by the IEEE but includes a massive range of online journals. This is both an advantage and a disadvantage. The advantage is obvious…we have access to far more good quality research papers published by a whole range of organisations. The disadvantage is that not all of these are not great quality papers and we do need to identify those published in referred journals or conferences i.e. the papers that have been quality checked and published by a reputable organisation.

The size of the database Google Scholar uses is not published but it could potentially index over over 100 million articles…which is of course massive!

For our purposes, finding quality research papers, it does have some limitations when compared with IEEE Xplore:-

- It will also find print based materials, books and other materials we are not interested in… though there is a way to exclude some of these from the search results.
- There is no easy way to exclude materials you will need to pay for or access via a library i.e. we cannot limited our search results to open access research papers.

Given this we do need to go through the search results to find the free to access research papers – this is not hard to do but it is a manual process.

Despite these limitations Google Scholar is a very useful tool that can help us find many open access research papers.

3.4 Learning How to Find Research Papers

Finding research papers is not quite as simple as just typing into a computer a few search terms. We also need to consider how to:-

- refine our search terms
- obtain a cohesive set of papers that are appropriate to our topic,
- refine the title of our paper given the specific papers we find and
- deal with papers that are not quite as relevant as others.

But the starting point is how we use the tools to obtain papers in the first place.

3.4.1 Using IEEE Xplore

IEEE Xplore may be of use to you for several reasons:-

- It provides access to over 3 million articles most of which are good quality research papers.
- You may be lucky enough to study at an institution that subscribes to these so all of these are free for you.
- Alternatively at least some are free.

For this reasons we will now learn the basics of using this tool now.

Activity 5

Watch the IEEE Xplore Tutorial: Searching with IEEE Xplore (5 mins).

http://youtu.be/KLttR8184_g

Feedback 5

There is no feedback for this activity.

Activity 6

Follow the link below to access IEEE Xplore
http://ieeexplore.ieee.org/

and follow the steps below to search for open access, i.e. free, research papers on medical diagnosis.

1. click on the 'Advanced Search' link.
2. in the first text box enter 'Medical Diagnosis' and click to search 'Full Text and Metadata' (see image below).
3. as we are looking for research papers only restrict the content types to 'Conference Publications' and 'Journals & Magazines' (see image below).
4. Then click 'Search'....don't' restrict the search to 'Open Access' just yet.

Feedback 6

The search should return over 65,000 articles...most of which are good quality research papers.

If you now click 'Open Access' and 'Refresh Results' you will find this now only returns about 200 research papers...but all of these are free.

Clicking on the pdf link should give you access to the full paper. Why not try this now?

You can of course refine your search in other ways.

For example: to ensure you find only current research papers you can to restrict the publication year to return only those papers published in the 2 or 3 years.

3.4.2 Using Google Scholar

As Google Scholar indexes a huge range of research papers some of which are free to access we will learn to use this now.

Activity 7

Watch the following video which teaches not only how to use Google Scholar but also how to check the papers you find are relevant to you (10 mins).

https://www.youtube.com/watch?v=bdRvEHg2DUs

Feedback 7

Google Scholar will find a huge range of resources and some are immediately accessible…others are freely accessible if you dig a little deeper.

This video also highlights an essential skill:-

It is critical you read the abstract, conclusions and discussion to determine how relevant a research paper is before trying the read the body of the paper.

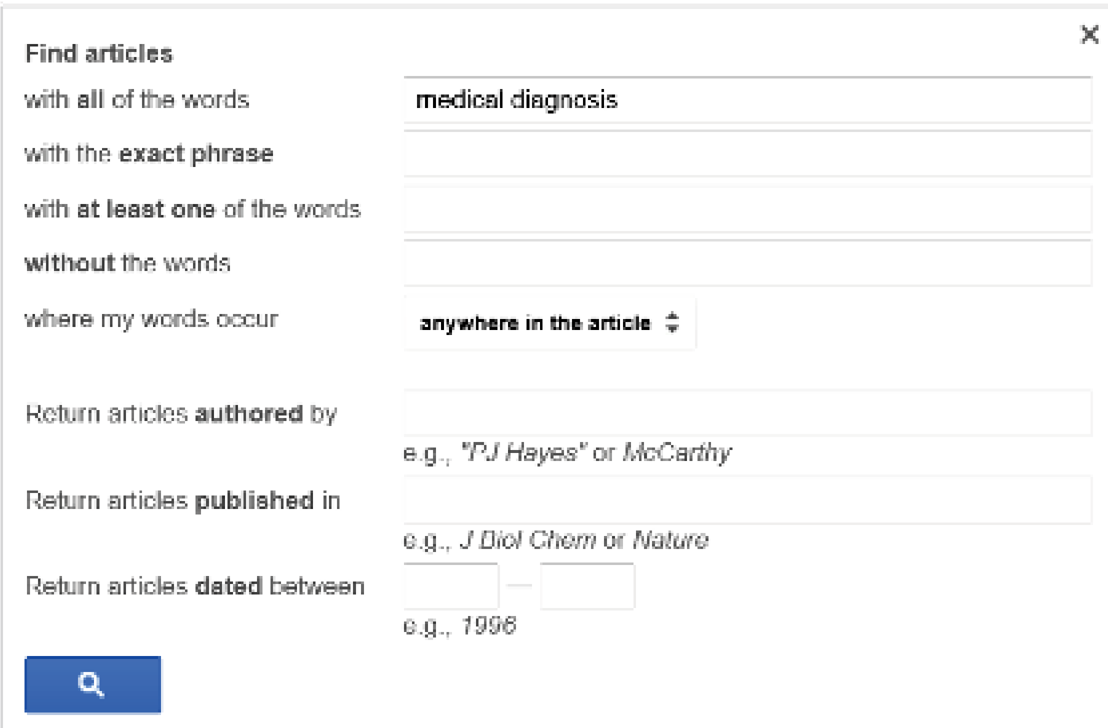
The body of the paper is often complex and presents a detailed and technical discussion of the research conducted. Eventually reading the main body is important as this will allow you to critically evaluate the science but there is no need to do this unless the paper is very relevant to your needs.

Activity 8

Follow the link below to open Google Scholar
http://scholar.google.co.uk/

and follow the steps below to search for open access, i.e. free, research papers on medical diagnosis.

1. click on the down arrow on the right of the search bar to bring up advanced search features.
2. in the first text box enter 'medical diagnosis' and set it to look for these words 'anywhere in the article' (see image below).
3. Then initiate the search.



Feedback 8

This search will return over 2 million results so we will learn how to narrow this down shortly.

For now we will just look at the results and try to identify open access research papers.

Activity 9

Look at your search results and try to spot the following labels…
[BOOK]
[CITATION]
[PDF]…this maybe on the left or on the right side of the page.

Feedback 9

We are not interested in books so ignore any item tagged with [BOOK].

Items tagged [CITATION] are not full articles but are references to books or research papers.

If you see a citation then clicking on this link will provide you with some details of that article concerned and also links to other more recent articles that have cited, or used, this article.

In some cases PDF links are available to open access versions of these other more recent articles.

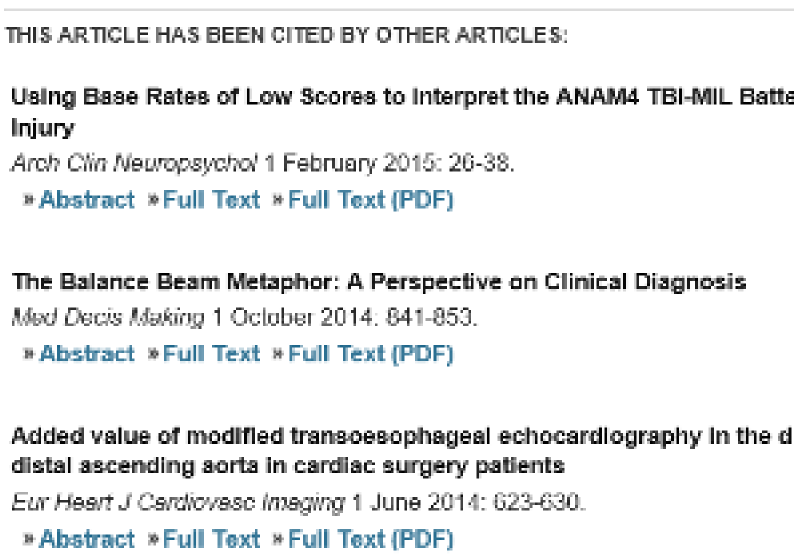
When I preformed this search I found a citation to a research paper "Reasoning Foundations of Medical Diagnosis Symbolic logic, probability, and value theory aid our understanding of how physicians reason". You can find this yourself by doing a search for papers with these words in the title.

Along with details of this paper were details of other papers that had cited this paper (see image below).

Of these 2 out of the first 3 PDF links gave me access to the full text or more recent papers that had cited this source.

By following links like these you can therefore find several related papers that describe research progressing on earlier work done by other researchers.

Clicking on the [PDF] link from the main search page in Google Scholar will also give you access to full research papers.


THIS ARTICLE HAS BEEN CITED BY OTHER ARTICLES:

Using Base Rates of Low Scores to Interpret the ANAM4 TBI-MIL Batt Injury
Arch Clin Neuropsychol 1 February 2015: 26-38.
» Abstract » Full Text » Full Text (PDF)

The Balance Beam Metaphor: A Perspective on Clinical Diagnosis
Med Decis Making 1 October 2014. 841-853.
» Abstract » Full Text » Full Text (PDF)

Added value of modified transoesophageal echocardiography in the d distal ascending aorta in cardiac surgery patients
Eur Heart J Cardiovasc Imaging 1 June 2014: 623-630.
» Abstract » Full Text » Full Text (PDF)

Activity 10

Repeat the previous search for papers with the terms 'medical diagnosis' in them.

Go through the first 50 search results and follow each of the PDF links.

Feedback 10

Your results will vary depending upon when you perform this search but you may find that within the first 50 results returned by Google scholar 10 or more PDF links to full text of open access papers.

Activity 11

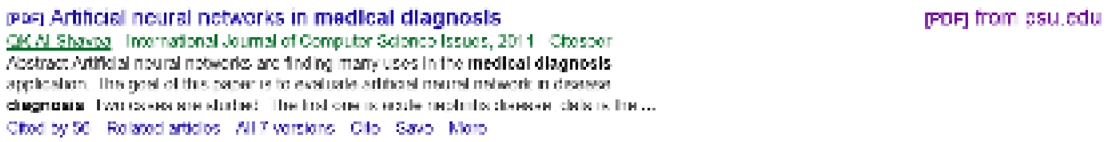
Now do a search for papers with 'Artificial neural networks in medical diagnosis'. Select 'in the title' not 'anywhere in the article' and restrict the search to papers published in 2011 by putting 2011 in both year boxes.

Feedback 11

Using this search you should find a paper written by QK Al-Shayea in the International Journal of Computer Science (see picture below).

If you follow the PDF link you should find not one research paper but a full volume of a journal made up of 91 research papers.

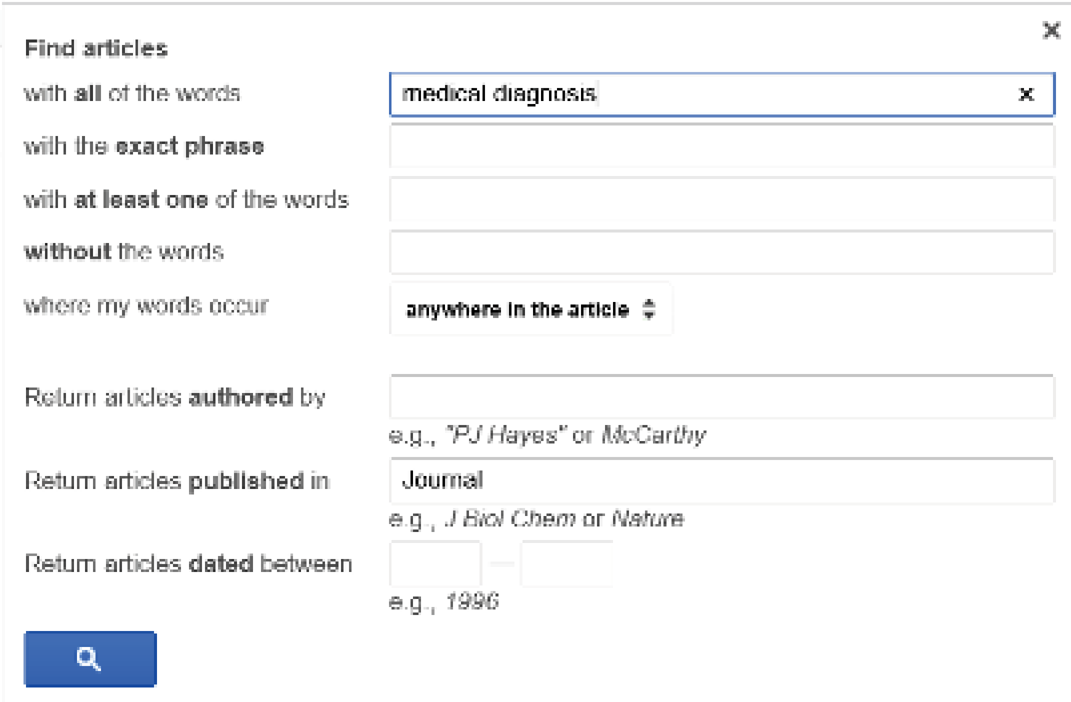
Though many relate to the application of neural networks they are on diverse applications and only a few would be relevant to our needs…but 4 or 5 of these papers are about the use of neural networks in medical diagnosis.



Activity 12

We will now repeat our search using Google Scholar and try to restrict the results to research papers published in journals or conferences.

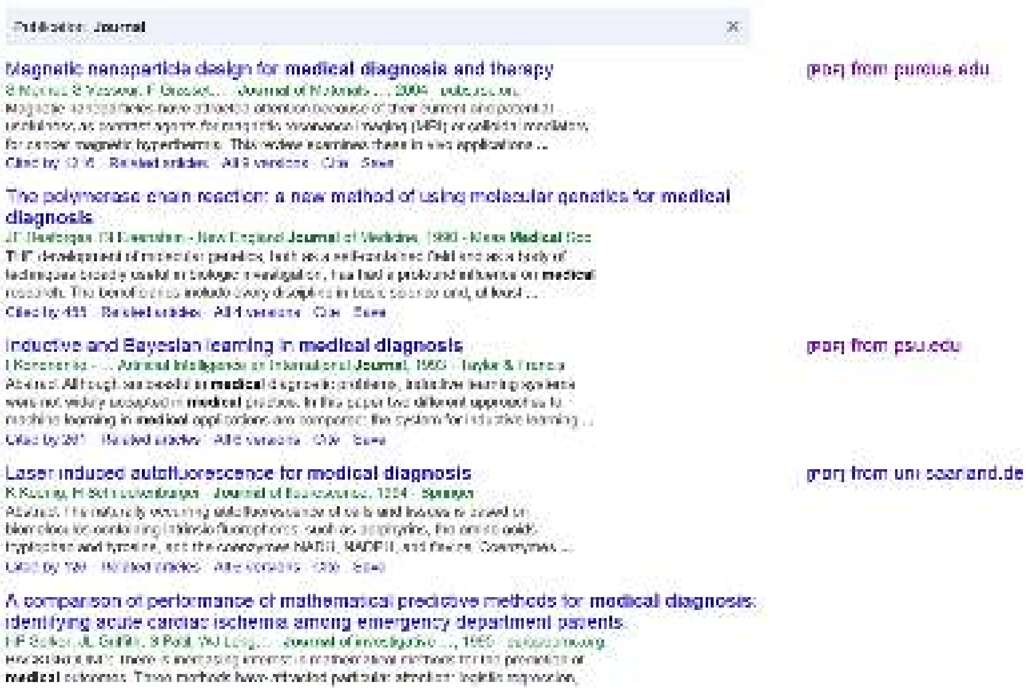
Repeat the search for papers on 'medical diagnosis', 'anywhere in the article' this time in 'Return articles published in' enter the word 'Journal' (see image below).



Feedback 12

This search will return lots of research papers all published in journals and many of these will still have links where we can download the full text of the paper (see image below).

We should repeat this search using the word 'Conference' to find papers published after research conferences.



3.5 How to Find a Coherent Set of Research Papers

By now, hopefully, you will feel confident that you can retrieve full copies of research papers via both Google Scholar and IEEE Xplore. However in order to obtain an appropriate set of research papers to meet your needs you also need to learn how to:-

- focus and adapt your search to obtain a cohesive set of papers,
- define an appropriate research paper title and
- refine your specific title to match the set of research papers you are using.

Developing these skills is the aim of the remaining part of this chapter.
Narrowing our search results…

Searching for conference or journal papers on 'medical diagnosis' using IEEE Xplore finds over 17,000 results and Google Scholar finds many, many more papers. So of course we need to refine our search.

There are two ways we can narrow this down immediately:-

a) specifying a date range to ensure we get only recent publications
b) look for articles with the words 'medical diagnosis' in the actual title.

Narrowing our search results in this way may well improve the search results by making them more relevant overall but does run the risk of excluding some useful material.

Of course if our original search terms are too stringent we may not get enough research papers and we may need to widen our search.

But what if you are not using the correct terms in the first place? Sometime we may need to use alternative terms altogether i.e. take a complete step in another direction.

So searching become a process of fishing…sometime narrowing our search, sometimes widening our search and sometimes stepping to one side.

Though search tools are a big help searching is not a simple process.

So having learnt to do a basic search and download the full text of papers we now need to learn how to refine our search terms and focus our research.

When searching for research papers it is usually a process of starting with a general idea and keep refining the search until you find a group of papers on one focussed and coherent topic that is of interest to you.

Activity 13

To develop your searching skills we will presume you are planning to write a paper on 'computer systems used for vision recognition tasks'.

1. Using either IEEE Xplore or Google Scholar or using both, do a search for Journal papers with 'Vision Recognition' in the title.

   This should result in a wide set of papers.

   Research papers are written for professionals and other researchers working in that field so many of the papers are complex – even the titles are complex – so don't worry if the titles look scary.

   Some of these papers may be unique and these will not easily be related to others but mostly you will find several papers that discuss related topics.

   Not all of these will be related to computer systems used for vision recognition tasks. Some of these will be about human vision problems and these papers are probably not relevant to computing researchers.

2. Now look at the titles of the first 50 papers returned and, **without worrying about any title that it totally confusing**, try to categorise the papers by identifying those papers that are on related subjects.

   You can either decide for yourself what the appropriate categories are or you can decide which papers fit into the categories below:-

a. Object recognition (varying objects)
b. Pattern recognition
c. Dynamic or real time vision recognition
d. Vehicle or road recognition systems
e. Robotic or machine vision
f. Text or handwriting recognition
g. Human or face recognition
h. Human gesture recognition
i. Accuracy of vision systems
j. Human vision, peripheral or medical problems
(these papers are probably not relevant to computing researchers).
k. Something else/no idea what this is about (**probably lots of these**)

Feedback 13

Hopefully you will recognise that many of the papers are on related subjects and more importantly several papers are about the same subject.

If you are to write about a cohesive topic it is important to be able to identify related research papers…obviously this is not easy if the topic is not familiar to you.

You may have noticed that many of the research papers you found in this exercise talk about Object Recognition, though the specific objects vary (face, traffic signs, characters or letters).

While the different objects vary the theories and methods for object recognition being tested in one paper could be compared with the theories tested in another. So papers are sometimes relevant and related even if they appear to be about a different topic.

Of course when we delve into these papers we will find that some are not as relevant as others and we will learn how to deal with these less relevant papers later. For now we will continue to develop our searching skills.

Activity 14

Using IEEE Xplore search for journal or conferences papers about 'computer vision' and 'object recognition' (see image below).

Feedback 14

You should now have a much shorter list of papers all related to computer vision and more specifically object recognition.

Activity 15

Look at the titles of the papers found and see which you could place under the following categories…

a. Pattern recognition
b. Object recognition (face, car number plates etc.)
c. Robotic vision
d. Computer vision
e. Face or human detection
f. Others…

Feedback 15

We started this exercise with a very wide subject 'Vision Recognition', we then focused 'Computer vision object recognition' and from this we can see that it is possible to focus our topic even further on any one of the subjects we identified from this e.g. pattern recognition.

However if we look in detail at the titles returned we see that we can focus our search even further perhaps by looking at one of the following…

- Robotic vision in manufacturing
- Number plate recognition
- Facial expression recognition

These are now nicely narrow and focused topics where we should be able to find a clearly cohesive set of research papers.

Of course starting from the very wide subject of vision recognition we could have found many other interesting focused topics.

We do need to continue refining our area of interest until we are happy we have found a cohesive set of papers on one narrow focused topic.

This is not always a process of defining ever narrower search terms. Sometimes we want to take a side step or widen our area of interest.

For example if we decided to look for papers on 'Robotic vision in manufacturing' we could consider other applications of computer vision in manufacturing and widen our search accordingly.

Often our original search terms are not the best as we don't know enough about the subject so we also need to look at the titles of the papers we find and look at the terms they use.

Activity 16

Continuing to use IEEE Xplore do a search for papers about 'Number plate recognition' we may want to change our search terms.

Feedback 16

Looking at the titles of the papers returned you may notice that some are about:-

- Using neural networks
- Character recognition
- Automatic parking
- …lots of others.

If we search for papers with 'number plate recognition' and 'Neural Networks in the title we would find only a very few papers but what if we were to widen our search and consider Neural networks used for any vision recognition task – not just in number plate recognition?

If we do a search for papers about 'Neural networks' and 'Vision Recognition' we will find research papers on various recognition tasks:- Object recognition, handwriting recognition etc., but all of which use neural networks to perform this recognition task.

Searching therefore throws up new terms we may want to consider.

Reviewing our search process we started our search with a very general topic:- 'Vision Recognition'.

We then focused our search on 'computer vision' and more specifically still on 'object recognition'.

We focussed further on 'Number plate Recognition'.

We then decided to change direction i.e. we took a step to one side, and considered the application of neural network theory.

At the same time we widened our search and considered the application of neural networks for any vision recognition task.

We did not need to stop there. We could have continued and focused on one of these recognition tasks… perhaps 'neural networks used for hand writing recognition'.

This process is not finished until we have found a cohesive set of research papers, i.e. journal or conference papers, on one narrow subject that we are happy with.

Searching for a cohesive set of research papers on a topic of interest is a process of repeatedly refining our search terms:-

- often becoming more specific,
- sometimes using new terms and taking a step to one side,
- and sometimes widening our search by becoming less specific.

Sometimes the general topic of our research paper will be fixed and this will provide the starting point for our search.

Sometimes the choice will be left entirely to you and you can pick a subject of interest to you.

If the choice is entirely open and you don't know where to start you can consider either picking one narrow topic from a text book as a starting point.

You can also consider combining words from two general subject areas, e.g. 'Information systems', with 'business needs'. This will help you focus your initial search.

3.6 Choosing a Title for Your Research Paper

It is possible that you will be required to write a research paper for which a title has been specified. In which case choosing the title is not an option and this will also constrain the searching process. You will still need to perform your own search for appropriate research papers and in doing so you may need to identify appropriate sub topics and find a few papers on each of these sub topics.

However if your title is not constrained then you need to choose an appropriate title for yourself.

As we have seen, given a general starting point, the searching process can lead you onto one of many focused subtopics any of which would be appropriate for a research paper.

Thus while you may define the general topic before you start your search you cannot define the precise title of your paper until you have found a cohesive and focussed set of research papers.

The title has to reflect the content of your discussion and analysis and thus reflects the content on the papers you use.

As you may have some choice or control over your research paper title we will now consider that makes an appropriate title.

Activity 17

Assuming that having started a search for research papers on computer vision we ended up with a cohesive set of papers on 'Neural Networks used for License Plate Recognition.

We could have found papers with the following titles:-

- "A fuzzy feature extractor neural network and its application in license plate recognition"
- "A modular neural network classifier for the recognition of occluded characters in automatic license plate reading"
- "A Neural Network Based Artificial Vision System for License Plate Recognition"

But essentially they are all about Neural Networks used for License Plate Recognition.

Remember, as we discovered in chapter 1, when writing a research paper we are not just summarising what we find we are trying to push forward the boundaries of human knowledge by presenting our evaluation of this research and our analysis, both of these require us to present our conclusions.

Given these research papers and given this is the task we are trying to perform consider the following proposed titles for our paper and decide which is the most appropriate:-

a. An Introduction to Automatic Number Plate Recognition Systems
b. A Technical Explanation of Number Plate Recognition Systems
c. A Critical Evaluation of Current Neural Network Theory for Number Plate Recognition Systems
d. Current Neural Network Research Aimed at Improving License Plate Recognition Systems

You may wish to put a tick next to any of the titles that you think is appropriate for a research paper.

Feedback 17

The first of these titles is wholly inappropriate – a basic introduction is not appropriate for a research paper. Research papers are aimed at professionals who already understand the basics. The reader of your research paper will want to know about current research and will also want to read your reasoned argument and analysis leading to your conclusions. There should be no introductory material in a research paper.

For a similar reason the second title is also inappropriate. This sounds more like a detailed explanation that would be provided to a student wanting to learn how to build such system not a review of current research.

If you could present a technical, clear and yet detailed explanation of how to write a computer program to recognize car number plates it would be impressive work – this is not a simple subject. However while this would be impressive and very useful for programmer it would not be a discussion/analysis of current research. It would not describe current research, it would not present your evaluation of current research nor would it present your conclusions from having evaluated current research. Therefore while this second title would be appropriate for a technical manual it would not be appropriate for a research paper.

The third and fourth of these titles are much better.

The 3rd highlights our role – which is not just to describe current research but also to evaluate this research and to report our conclusions.

The 4th title does not highlight our role but does highlight the fact that our paper will present a review of current research.

Not all titles need to use the word 'research' nor do they need to use the words 'critical evaluation' but the title you choose for your paper should:-

- reflect the narrow subject matter and
- reflect the purpose which is to present your analysis and evaluation of current research.

3.7 Choosing a Title for a Dissertation Research Chapter

If you are writing a research chapter as part of a larger dissertation its title should also:-

- reflect the subject matter and
- reflect the purpose which is to present your analysis and evaluation of the research.

However a research chapter is likely to be much longer than a research paper and therefore while each subsection should be equally focussed the overall title maybe more general.

For example the overall title may represent current research on number plate recognition systems with sub sections devoted to the application of neural network theories and other competing methods.

While the chapter sub section titles will therefore be equally focussed the overall chapter title will be more general.

3.8 Other Resource Discovery Services such as the Directory of Open Access Journals (DOAJ)

So far in this chapter we have focused on two Resource Discovery Services that provide access to open access research papers, Google Scholar and IEEE Xplore, but there are many other Resource Discovery Services available and some of these may be more appropriate to your needs.

Many of these specialise in particular subjects such as agriculture, chemistry, economics, education, medicine, philosophy and psychology and therefore may provide excellent focused results if you are studying one of these subjects.

Activity 18

Follow the link below to a Wikipedia article on Resource Discovery Services

http://en.wikipedia.org/wiki/List_of_academic_databases_and_search_engines

Look down the list to see if any of these specialise in your subject area.

Feedback 18

There is no feedback for this activity.

Activity 19

Follow the link below to the Directory of Open Access Journals (DOAJ)

http://doaj.org/

and try out a couple of simple searches to see if it returns any research papers in your subject area.

Feedback 19

The Directory of Open Access Journals (DOAJ) is one of the resources listed in the Wikipedia article. It does not specialise in a subject area so you need to decide for yourself if searching this is better than using Google Scholar…perhaps you can use both.

3.9 Summary

In this chapter we have learnt that research papers often have an unexpected starting point.

We often don't start with a title. While we start with a subject or topic – hopefully quite a focussed topic – the actual title should be refined to reflect the specific papers we find at the end of the searching process.

We learnt how to use IEEE Xplore and Google Scholar but we also found that other Resource Discovery Services such as the Directory of Open Access Journals (DOAJ) exist some of which specialise in different subject areas.

You could be studying at an institution or university which provides a specific resource discovery tool that is more appropriate to your needs however IEEE Xplore and Google Scholar are still both useful and good alternatives you may want to consider using as well.

We learnt how to find papers using these tools and restrict our searches so that we concentrated on finding good quality research papers i.e. those published in journals and research conferences.

We then learnt how to search for a cohesive set of papers, often focussing our search, sometimes taking a step to one side and sometimes widening our search. In doing this we used search terms we found in the titles of the papers recognising that we may start our search process not knowing what the best search terms are.

Finally we considered what makes an appropriate title for a research paper or research chapter…one that reflects the research content and one that reflects the purpose of our paper which is to present our evaluation, our analysis and our conclusions.

Having learnt how to find a cohesive set of research papers we must learn how to analyse and evaluate them but first we must learn how to read them i.e. what we are looking for when we read them. In order to learn this it would help if we had some understanding of research methodology and this therefore is the subject of the next chapter.

4 Research Methodology

Introduction

In chapter 1 we learnt that:-

- the purpose of research was to push forward the boundaries of knowledge
- knowledge was true justified belief

From this we learnt a simplified scientific process:-

- Observe something that can't be explained by our current knowledge.
- Provide a suggested explanation for this phenomenon…we call this suggested explanation a hypothesis.
- Test the hypothesis to find out if it is really true.

We also learnt that to write our own research paper we will be expected to critically evaluate other research papers and this requires:-

- an evaluation of research methods,
- evaluating the discussion of results and
- evaluating the conclusions reached.

All of this requires a deeper understanding of:-

- research theory,
- how research should be conducted and
- the importance of experiments and experimental design.

This chapter aims to expand our understanding of research theory and to discuss the basics of experimental design. This will enable us to understand more about what we see when we look at research papers.

We will come back and look at the subject of experimental design in more detail later so we can understand more about how to critically evaluate research.

For now our purpose is just to ensure we understand enough research theory so we can understand what we are looking for when we read research papers.

Objectives

By the end of this chapter you will be able to…

- Understand the principles behind good research
- Understand some of the ways research can be conducted
- Explain some of the ways research can be flawed.

This chapter consists of 15 sections:-

1) Research…an analogy
2) Scientific Method
3) Scientific Principles
4) Controlled Experiments
5) Empirical Research
6) Basic Research Criteria
7) Basic Research v's Applied Research
8) Qualitative v's Quantitative Research
9) Project Types
10) Alternatives to Laboratory Based Experiments
11) Data used to Generate a Hypothesis Cannot be Used to Verify the Hypothesis

12) Testing the Null Hypothesis
13) Testing Our Understanding of the Concepts
14) Flawed Research
15) Summary

4.1 Research…an analogy

Our discussion so far states that the aim of research is to push forward the boundaries of human knowledge.

And that to do this we must:-

- Observe something that can't be explained by current knowledge.
- Provide a suggested explanation for this…a hypothesis…and
- Test the hypothesis to find out if our explanation is really true.

If we are making a contribution to human knowledge it implies we are not working in isolation but are basing our work on existing work.

We want to add a piece of knowledge to the existing body of human knowledge.

By analogy we are trying to build a wall. To do this we need to:-

- know where to place the next brick.
- and we need to test the brick we are putting in the wall to ensure it is strong enough

Knowing where to place the next brick implies we must first read some research papers. Research papers show where the current gaps in our knowledge are.

Ensuring our brick is strong enough, implies we are testing our claims for knowledge, via experimentation or other form of proof, to ensure the claims we make are accurate and won't be disproven by future researchers who are building on top of our part of the wall.

We need to do this testing in a rigorous, scientific, professional and competent way…so other researchers who are evaluating our research, e.g. others like you who maybe writing a research paper, will recognise the validity of our work.

If we don't conduct our research in a competent way other researchers will identify our mistakes and cast doubt on our conclusions. To prevent this we need to follow a sound scientific method.

Either way researchers will evaluate our work and make a contribution to knowledge by confirming the validity of our conclusions or by highlighting issues/problems.

4.2 Scientific Method

Scientific methods do partly depend upon the discipline or subject area of the researcher thus:-

- Researchers working with human blood or human tissues will have certain protocols they must follow determined by the requirements of medical ethics.
- Researchers working on archaeological digs will follow certain protocols to uncover and catalogue evidence to ensure the evidence is not damaged or inaccurately recorded.
- Researchers working in human psychology will have standard methods for collecting subjective personal feeling and analysing these with appropriate statistical techniques to ensure the results are free from bias.

Whatever the subject area though most research projects in the scientific disciplines follow the same set of steps:-

- Analyse the problem or observe unexplained phenomena
- Find out what current researchers propose by reading the literature
- Make a prediction about what will work best or about what will explain previously unexplained phenomena (i.e. develop the hypothesis)
- Test this hypothesis by either
    - Conducting a controlled experiment.
    - Implementing a solution and testing this solution in the real world.

- o Making a prediction based on the hypothesis and testing this prediction by collecting evidence that will prove or disprove the prediction.
- o Provide a mathematical or other formal proof
- On the basis of the test results reach conclusions about the validity or otherwise of the hypothesis and make claims accordingly

Testing the hypothesis will often involve:-

- performing experiments,
- collecting data from the experiments,
- analysing the results and
- drawing conclusions from these results.

4.3 Scientific Principles

There are two fundamental ways of collecting scientific data:-

- pure observation – in a non-invasive way
- experiment – introducing changes and observing the effects

Whether a researcher is performing experiments or collecting data by observation researchers must follow basic scientific principles:-

- Empirical – evidence is obtained by observation and measurement.
- Measurement – we are measuring what is observed in some way and these measurements must be accurate made and properly recorded.
- Non Invasive – we must ensure that the process of data collection does not impact on the data itself. If you monitor staff at work to determine how much time is wasted taking unauthorised breaks you can imagine that staff will avoid taking breaks while being watched. The process of monitoring the staff is therefore invasive and this will affect the results.
- Objectivity – we try to avoid introducing any form of subjective bias as this will invalidate our data and results.
- Repeatability – we seek to ensure our methods are properly documented so other researchers can replicate our experiments and verify our results.

Thus when you are evaluating research conducted by others you should be asking 'Have they followed these good scientific principles?'

If not it will cast doubt on the conclusions those researcher reached.

4.4 Controlled Experiments

Researchers like and often conduct controlled experiments as these are relatively easy to perform and show that the researcher has sound scientific evidence to support their conclusions.

A controlled experiment is one where control is maintained over all the variables that could influence the results and only one of these variables is altered. Simply put two identical experiments are conducted under identical conditions but where one of the conditions or variables, the one being tested, is changed.

An example would involve using two groups of patients to test a new drug:- a test group and a control group. The two groups of patients should be identical…and to ensure this patients should be randomly assigned to each group. Both groups must be treated in an identical way with one exception:- the test group is given the new drug and the control group is not.

It could be easy to introduce bias into such an experiment. Medical researchers could put the patients most likely to improve into the test group…and thus the results would be biased in favour of the new drug. The two groups of patients could also have different expectations…if one group knows they have been given the drug their expectation, or belief, is that they will improve and this will impact on the results they report. If the researchers know which group a patient is in that could also influence the way they interact with the patient and thus affect the results.

To avoid all of these potential sources of bias the concept of a double blind trial was developed. A double blind trial is one where both the tester, i.e. the medical researcher, and the subject, i.e. the patient, is unaware who is in the control group and who is in the test group. For this to work the patients in the control group must be given a placebo i.e. a dummy medicine that has no medical effect.

For practical or ethical reasons it is not always possible to conduct a controlled experiment. Testing a new cars sales strategy under perfectly controlled conditions would require two identical car sales businesses or at least two identical departments…selling exactly the same products, working in the same way, with the same sort of clientele, under the same economic circumstances and with the same management and sales teams. Clearly it is not possible to find two absolutely identical departments. A comparative experiment can still be undertaken but the researchers must take care to ensure the uncontrollable differences are as small as possible and do not influence the results.

When evaluating research you cannot jump to the assumption that failure to undertake a controlled experiment implies bad research nor can you assume that doing a controlled experiment means the research is sound, as bias can still be introduced. Still controlled experiments can provide sound scientific evidence for conclusions

4.5 Empirical Research

Empirical research is research that bases its findings on direct or indirect observation, for example a kettle uses electricity to make heat water…but how much electricity does it take to heat the water?

- How do we observe or measure the amount of electricity?
- How to we measure the change in water temperature?
- Will we think to measure the amount of water involved and how will we measure that?

We can of course use an electricity meter, a thermometer and a measuring jug.

We need to be sure the measurements are accurate so we must check any instrumentation involved works by calibrating it.

To ensure the thermometer is working properly we must calibrate this. We know that water boils at 100 degrees C and water freezes at 0 degree C so we can check our thermometer measures freezing water and boiling water accurately and this will give us some reassurance that it works in between these temperatures as well.

…Actually at low atmospheric pressures, e.g. on top of a mountain, water boils at lower temperatures so we do need to exercise some caution when calibrating equipment.

When taking measurements direct observation is always desirable but not always possible. Direct observation means we can directly measure the things we want to measure i.e. the temperature of the water, the water volume and the amount of electricity being used.

However direct observation is not always possible and in these situations we need to take indirect measurements.

Clearly we can't measure the temperature at the centre of the Sun directly. We can however measure the radiation levels coming from the Suns surface and perhaps using these we can determine the temperature at the centre.

Indirect measurements are sometime necessary but again we must exercise caution…if we are making claims based on the temperature at the centre of the Sun and this is based on indirect measurements can we be sure that our assessment of this temperature is accurate?

We also need to be careful if we are relying on human senses.

Sometimes we do need to rely on human senses e.g. bird watchers look out for unusual birds and this data can be useful to predict changes in migration and feeding patterns…and these could be an indication of climate change.

We need to rely on this information as there are many practicing birdwatchers and we can't put cameras everywhere but we must be careful to ensure that the data is not inaccurate. If a novice ornithologist cannot recognise the difference between a Peregrine Falcon and a Prairie Falcon they may report inaccurate sightings.

In this situation we could of course wait until the data has been corroborated by other ornithologists.

Rather than rely on human senses where possible it is better to take accurate measurements using calibrated equipment.

We could be doing research to see which traffic calming measures are most effective in slowing down cars in residential areas…in this case there is clearly no need to rely on human reports of speeding cars. We can accurately measure this, using speed cameras, but we still need to ensure that the speed cameras are calibrated and working correctly and the data is free from bias.

If the speed cameras are clearly visible then drivers who are speeding will slow down and the data we collect will be biased and will not accurately reflect the normal speed of cars.

Collecting evidence for, or against, any particular theory requires systematic collection of empirical data, and academic rigor plays a large part to ensure the research being undertaken is being done properly.

4.6 Basic Research Criteria

While research will vary depending on the subject or research discipline all research should satisfy basic criteria:-

- Purposeful: the research should have a clear goal and the research should be conducted in a well defined way to meet this goal.
- Rigor: the research should be conducted using a thorough, systematic approach and this approach should be critically evaluated to look for potential flaws.
- Testability: remember knowledge is true justified belief so a hypothesis is not just any theory. A hypothesis is a theory that can be tested. Thus research means investigating theories that can actually be evaluated.
- Reproducibility: The research approach and methodology should be clearly documented so other researchers can follow the same process to make sure that the results can be reproduced with some degree of reliability.
- Precision: We must make sure that the measurements are precise as is possible given the circumstances and all results. Both negative and positive, should be properly recorded.
- Objectivity: we must ensure that we don't introduce any bias into the investigation.
- Confidence: considering the issues of rigor, testability, reproducibility, precision and objectivity we are trying to ensure that we can have confidence in the results and that they are meaningful.

There are two additional criteria researchers should aim to satisfy:-

- Generalisability: We want to ensure we get results that have a wider impact than the immediate experiment that was carried out. For example we may restrict the fat content in the diet of mice to measure the effect this has on them but from this experiment we may want to make claims about the diet and associated health benefits on humans but mice are not humans and we must be careful to ensure general claims we make are justified by the evidence we have.
- Parsimony: Occam's razor is a philosophical principle that says we should accept the simplest hypotheses that explains the facts. Related to this is the research principle of 'Parsimony' which suggests we should adopt the simplest possible theory with the greatest predictive power. For example we may note that among cancer patients there is a greater proportion of smokers than in the general population. Two hypotheses that would explain this are a) smoking causes cancer or b) cancer patient's smoke to distract themselves. Of these two potential hypothesis the first has a massive predictive power…if this is true then we can reduce cancer and suffering by reducing smoking. The second of these hypothesis has less predictive value and is also a more complex hypothesis…a) do patients want to be distracted? b) why would smoking distract them c) would something else not distract more? The principle of Parsimony suggest we should accept the first of these hypothesis as our working hypothesis…it does not suggest we should accept this hypothesis as true – we still need to verify this.

All research should satisfy these basic principles but this does not mean all research papers look the same. Research papers will vary as the nature of the work they report varies.

Research can be categorised according to basic groupings:-

- Basic or Applied
- Qualitative or Quantitative

It is worth understanding these basic types of research as these are reflected in the content of the research papers you will need to read.

4.7 Basic Research vs Applied Research

Basic research does not mean 'simple' research. It is sometimes called pure or theoretical research and is research that is being done to understand fundamental principles or the phenomena of a subject. It is often undertaken without any thought given to the practical application of the theory and is often not tested by applying the theory to a problem but tested by developing mathematical proofs.

Applied research on the other hand is very much focussed on solving practical problems or considering the practical application of theory. These cannot be studied without considering issues to do with the implementation of the theory and are often therefore tested by apply the theory to a specific problem or product. Most research is of this type.

Activity 1

Consider the following research problems and categorise them as basic or applied:-

1. Understanding the laws of physics that govern the behaviour of black holes.
2. Developing new materials, stronger and lighter, to make cheaper rockets that can transport humans to the moon.
3. Understanding human perception of business confidence

Feedback 1

1. Understanding the laws of physics that govern the behaviour of black holes.

   This is basic or fundamental research. It is considering the fundamental laws of the Universe and there is no thought given to any practical application of any knowledge gained from such research…but who knows what may come from enhancing our understanding of these laws. Perhaps one day we will find out that time travel is possible!

   In this research our hypothesis would probably come in the form of a mathematical model describing our theory to explain the way a black hole works. But a hypothesis is a testable theory and clearly we cannot test any theory by dropping a probe into a nearby black hole to measure what happens at the centre…thankfully none are close enough but also a probe would not be able to send any data back out.

   While we cannot test any hypothesis by measuring what happens at the centre of a black hole we could measure what goes on near the periphery but if it was the data coming from the periphery that led to the development of the model in the first place then we must find some other way to prove our model is correct.

   Mathematical contradictions would prove our model was flawed but failing to find any mathematical contradictions would not be sufficient proof. Another test would be to make predictions based on the mathematical model and test these predictions in a lab.

   The following link describes how the Higgs Boson particle, sometimes referred to as the God particle, was predicted to exist in 1964 but was not until 2012 that the particle was actually observed to exist in CERN…a fairly large and impressive lab.

   http://en.wikipedia.org/wiki/Higgs_boson

2. Developing new materials, stronger and lighter, to make cheaper rockets that can transport humans to the moon.

   This is applied research. It has a clear practical and useful goal but also needs to be tested by practical application e.g. build components with the new materials and test them for durability, heat resistance etc when compared with components developed with the older materials.

3. Understanding human perception of business confidence

   While this may not be research that is aimed at understanding fundamental laws of physics it could be research that aims to understand fundamental principles of human perception or fundamental aspects of human psychology that affect our feelings of confidence. Thus this could be basic research but we could also consider the practical application of this knowledge.

   Basic research may consider the biology of the brain, the mechanisms for perception or the psychology of feelings. Theories regarding these maybe tested in a medical lab using neurological scanning and other appropriate devices, or tested by developing models of psychology, making predictions based on these models and testing these predictions.

   Alternatively applied research may consider the practical issues that impact upon business confidence with a view to increasing confidence and hence investment and hence jobs. Theories could be tested by developing models of business confidence and testing the accuracy of such models when faced with real world scenarios.

4.8 Qualitative vs Quantitative Research

We can also categorise research as Qualitative or Quantitative.

Quantitative research is where we can take numerical measurements i.e. do experiments that involve making clear measurements and where we can gather numerical data and process the results numerically.

For example: we could undertake research to develop more fuel efficient car engines and we can take clear measurements to assess efficiency e.g. we can measure the distance a car can travel at a specified speed for a given quantity of fuel.

Qualitative research is where there are no clear measurements or numbers. Here we may need to develop scales and collect large quantities of data to ensure we have valid data.

For example: if we are to undertake research to develop more comfortable car seats we cannot clearly measure comfort. For this we would need to develop a suitable scale (1 – Very Uncomfortable, 2 – Uncomfortable, 3 – Neutral, 4 – Comfortable, 5 – Very Comfortable) and get the perceptions of numerous people, testing seats in numerous shapes made from a range of materials etc to determine what makes a comfortable seat.

As people perceptions differ we would need to gather data from enough people to gather a realistic view of a population. We would also need to repeat this data collection with different groups, male adults, female adult and children, as different body shapes will lead to different results. We may also need to consider different races and cultures as cultural expectations may impact on perceptions of comfort.

4.9 Project Types

As well as Basic or Applied/Qualitative or Quantitative research can also be loosely categorised depending upon the way a research project is conducted:-

- Theoretical or Basic Research
- Experimental Research
- Survey Based Research
- Action Based Research
- Strategy Based Research

Though these are general categories and some projects may combine features from more than one of these types.

The practical work conducted will be reported in the research papers you will read and understanding a little research theory here may help you to understand these papers better.

4.9.1 Theoretical or Basic Research

Research papers that describe theoretical or basic research will usually describe:-

- relevant concepts with suitable examples,
- the making and testing of conjectures,
- the development of theorems and proofs, where appropriate, and
- consideration, where possible, to the application of the theory to practical problems.

These papers will rarely describe any practical implementation of the theory.

As a hypothesis is often tested by mathematical proof or the testing of a mathematical model these papers can be very mathematical and very difficult to understand for researchers without sufficient mathematical/logic knowledge.

4.9.2 Experimental Research

Experimental research projects involve the investigation and evaluation of a specific technology.

This may involve the development or implementation of a substantial test product and the application of scientific measurements to ascertain its properties and usefulness.

Reports on such projects will describe:-

- the theoretical foundations (taken from the literature),
- a discussion of the problems of existing methods and how the new ideas may overcome these problems,
- a description of the implementation and the experimental procedures used,
- evaluation of the implementation and
- an analysis of the results

4.9.3 Survey Based Research

Some projects in less technical domains may be survey based e.g. a survey of organisations or people.

Reports on this research would include information on:-

- The design of the survey
- The survey sample (usually quite large)
- The data collection and
- Statistical analysis of this

4.9.4 Action Research

Action research projects involve studying an organisation or populations and are used to investigate a phenomena which is not fully understood. The purpose is to study the organisation and implement some action, i.e. to make a change, and observe results.

The benefit from this will be a deeper understanding about an organisation and insight about the impact of the change.

Research papers that describe this sort of research will often include information on:-

- A case study of one organisation
- A set of interventions and observations about their impact
- An analysis of these and the conclusions coming from this.

4.9.5 Strategy Research

In domains like management another type of project can typically be found that involves the development of strategies. The typical key components of such projects are:-

- Development of a case study of the target organisation
- Identification of requirements and needs of the organisation
- Development of a strategy
- Critical evaluation of the strategy

Ideally the effects of the strategy would be assessed by:-

- Determining key performance indicators
- Collecting data before any intervention
- Collecting data after the intervention

though timescales may not permit this in practice.

4.10 Alternatives to Laboratory Based Experiments

Our scientific method involves:-

- Analyse the problem or observe unexplained phenomena
- Find out what current researchers propose by reading the literature
- Determine our hypothesis
- Test this hypothesis

And we can see from looking at the different types of research project that testing the hypotheses can involve:-

- Implementing a solution and testing this solution.
- Making a prediction based on the hypothesis and testing this prediction by collecting evidence that will prove or disprove the prediction.
- Provide a mathematical or other formal proof

And testing the hypothesis will often involve:-

- performing experiments,
- collecting data from the experiments,
- analysing the results and
- drawing conclusions from these results.

Activity 2

From the theory above we can see that testing a hypothesis can involve alternatives to laboratory based experiments. Consider the following types of research project:-

a. Theoretical or Basic Research
b. Experimental Research
c. Survey Based Research
d. Action Based Research
e. Strategy Based Research

and identify for each which of the following methods could be used to test a hypothesis:-

1. a laboratory based test
2. a practical real world test
3. a mathematical proof.
4. a statistical analysis of a large data set.

Feedback 2

a. Theoretical or Basic research is often tested by providing a mathematical proof. We will discuss this further in the next section.
b. Experimental Research which may involve testing a product or technology could be done in two ways. A controlled experiment in a lab can test the item under controlled conditions to allow comparison with older products/technologies. Alternatively performing the testing in real world conditions will allow the performance of the item to be assessed when under real world conditions.
c. Survey Based research involves statistical analysis of large data sets but care must be taken to ensure the analysis does not lead to false conclusions.
d. Action Based research involves implementing a change within one organisation and measuring the impact of this change. This is a real world test but it is difficult to control this test and care must be taken to ensure that other changes that have occurred naturally during this time do not have a spurious effect on the results.
e. Strategy Based research will ideally involve a real world test:- implementing the strategy, at least within 1 part of the organisation, and measuring the impact of this. As with action based research we must be sure that other natural changes occurring over the same time period do not cause spurious results. If it is not possible to implement the strategy it is still possible to assess the potential impact of this by doing a cost/benefit analysis or some other analysis but we must take care to ensure that this assessment is reliable.

You may see from this that testing our hypothesis can involve a range of activities, not just laboratory based activities, and these activities can be complex and error prone. It is for this reason we cannot trust conclusions other researchers reach but we must evaluate the methodologies the researchers followed and we will come back to this important subject in more detail later.

For now we will just consider two final but important scientific principles:-

- Data used to generate a hypothesis cannot be used to test the hypothesis
- We should also test the Null Hypothesis.

4.11 Data used to Generate a Hypothesis Cannot be Used to Verify the Hypothesis

Fundamental research that was done in the 1960s that led to the detection of the Higgs Boson particle in 2012, see http://en.wikipedia.org/wiki/Higgs_boson for details of this.

This research exemplifies the application of a very important scientific principle:-

Data, or unexplained phenomena, used to generate a hypothesis
cannot be used to verify the hypothesis

In this research previously unexplained phenomena within the field of physics led to a proposed model for physics called the Higgs field.

Mathematical contradictions in the proposed scientific model would have led to its rejection but no such contradictions were found. Indeed the proposed model explained several long standing and previously unexplainable phenomena.

However while the model explained the observed phenomena this was not taken as proof the model was valid.

As the model was specifically developed to explain the observed phenomena it is of course not surprising that these observations do not contradict the model proposed. Some other evidence was needed to prove the model was accurate. Based on the model the researchers predicted the existence of the Higgs Boson particle – when this was found 50 years later this was accepted as sufficient verification of the hypothesis.

It is easy to forget this important principle reach flawed conclusions and present these as valid research. Imagine the following scenario:-

A survey is conducted of a significant number of people. Everything about their life style is measured (what they eat, what they wear, what they use and what they do) and this is compared against the illnesses they have, their educational results and their employment prospects. If we take this large amount of data, correlating everything measured against everything else measured, we will probably find two things that seem to be highly related.

Purely by chance we will probably find something…perhaps the people born on Monday were promoted quicker…perhaps people who use blue ink in pens get more colds or flu-like symptoms. A statistician looking at all of this data would understand that random chance will make something seem to be related to something else and this is not statistically significant.

Still a poor researcher could reach the conclusions that the use of blue ink is related to suffering from flu-like symptoms and reach a hypothesis that some chemical in the ink is responsible. They could then present this data to 'prove' this hypothesis is valid…worse still if they fail to report all of the other data collected they could make this look statistically significant.

But remember:-

Data, or unexplained phenomena, used to generate a hypothesis cannot be used to verify the hypothesis

If we reach the hypothesis that a chemical in blue ink leads to flu-like symptoms then we need to find some alternative data to prove this. This would be easy to do. Find an entirely different group of people and conduct a survey to look specifically at this issue – and of course if we did this we would find no relationship exists i.e. the use of blue ink does not cause flu-like symptoms.

But how often do we see research reported in the press along the lines of a survey showed that X causes Y?

…and the data shows a strong correlation!

Bad science is easy to do and easy to report. Hence why we need to understand the scientific principles and evaluate the way the research was conducted for ourselves.

4.12 Testing the Null Hypothesis

Another scientific principle involves something simple but rather grandly called the Null Hypothesis. The Null Hypothesis is the opposite of our hypothesis.

In essence rather than looking for positive affirmation it is often better to try and disprove our hypothesis… failure to disprove the theory often provides stronger evidence that the theory is true.

We call this testing the Null Hypothesis.

Activity 3

Follow the link below and watch the YouTube video 'Can you solve this?' (5mins)

https://www.youtube.com/watch?v=vKA4w2O61Xo

This provides an excellent example of why we should test the Null Hypothesis.

Feedback 3

Rather than trying to prove our hypothesis we often get stronger evidence by trying hard to disprove it and failing to do so.

Let's take a simple example…If a car designer wishes to prove the car design is secure the best proof is to try and actively prove it is not secure (the Null hypothesis). If the car designer recruits experienced and very able car thieves and if they can't break into the car then this provides strong evidence that the car is secure.

Trying, yet failing, to prove the Null Hypothesis gives us stronger evidence that the Hypothesis is valid.

In a research setting imagine we notice that some well paid staff seem really keen on their jobs and some poorly paid staff seem to have low levels of motivation and from this observation we develop the hypothesis that staff pay affects staff motivation levels. Thus if we want well motivated staff we need to pay them all well.

But were the staff motivated by their pay or were they already motivated and because they were motivated staff who worked hard they were promoted and became well paid? In other words did the pay cause the staff to be well motivated or did the fact that the staff were well motivated cause then to earn higher rates of pay?

We could try to prove that pay affects motivation levels and in doing so we would indeed find evidence that some well paid staff are well motivated but this is weak evidence. Surely we could also find some well paid staff who are not well motived?

The Null Hypothesis, i.e. the opposite hypothesis, is that pay levels do not affect staff motivation levels. Trying to prove this may help us to prove our hypothesis.

We could try to prove that pay does not affect motivation levels by taking a range of staff working in comparable jobs where the only difference is rate of pay and measure their motivation levels.

For example take two groups of teachers working in similar schools, teaching the same subjects with the same class sizes and same resources…but where one group is better paid. Repeat the experiment for other groups of staff – factory workers, bus drivers, etc.

Remember we are trying to prove that the difference in pay rate is not affecting the levels of motivation. If however our results show that the Null Hypothesis is false then we have strong evidence that the hypothesis is true…i.e. pay does affect motivation levels.

Rather than looking for a few positive examples, that pay affects motivation, we are looking for examples where pay does not affect motivation. If we can't find any examples where pay does not affect motivation then we have much stronger evidence that pay does affect motivation.

Failure to disprove the Null Hypothesis therefore gives us stronger evidence that the hypothesis is valid.

4.13 Testing Our Understanding of the Concepts

In this chapter we have looked at scientific principles and a little into how research is conducted for two reasons:-

- Understanding this will help us to understand what we see in research papers and
- Understanding this will help us to evaluate the research for ourselves.

The following exercise will help you to test your understanding of the concepts covered here.

> **Activity 4**
>
> Draw a line between matching phrases and meanings in the list below to check you understand these terms (one has been completed for you).

Phrase	**Meaning**
Basic research	Investigating problems where we cannot collect clearly measurable data but where we may need to develop our own scales (e.g. comfort ratings) and collect large quantities of data to ensure meaningful results.
Applied research	Investigating problems where we can collect clearly measurable data that can be processed numerically.
Quantitative research	Investigating fundamental principles. Often tested theoretically by developing logical mathematical proofs.
Qualitative research	Investigating practical problems by looking at specific cases.
Knowledge	Taken all together we can be sure the experimental results show what they claim to show.
A hypothesis	Problems that can be evaluated.
Testability	Making sure others have enough information to repeat our experiments.
Reproducibility	True, justified, belief.
Precision	If we repeat the experiments we will get the same results.
Objectivity	The conclusions we reach will have an impact beyond this specific situation being tested.
Validity	A suggested explanation.
Reliability	Making sure experiments get accurate data.
Significance	Removing any bias from an experiment (e.g. personal opinion).

Feedback 4

The solution to this activity is provided below:-

Phrase	Meaning
Basic research	Investigating problems where we cannot collect clearly measurable data but where we may need to develop our own scales (e.g. comfort ratings) and collect large quantities of data to ensure meaningful results.
Applied research	Investigating problems where we can collect clearly measurable data that can be processed numerically.
Quantitative research	Investigating fundamental principles. Often tested theoretically by developing logical mathematical proofs.
Qualitative research	Investigating practical problems by looking at specific cases.
Knowledge	Taken all together we can be sure the experimental results show what they claim to show.
A hypothesis	Problems that can be evaluated.
Testability	Making sure others have enough information to repeat our experiments.
Reproducibility	True, justified, belief.
Precision	If we repeat the experiments we will get the same results.
Objectivity	The conclusions we reach will have an impact beyond this specific situation being tested.
Validity	A suggested explanation.
Reliability	Making sure experiments get accurate data.
Significance	Removing any bias from an experiment (e.g. personal opinion).

4.14 Flawed Research

While all research should satisfy basic scientific criteria some does not and there can be several reasons for this:-

- Intentional errors caused by biased researchers who may be funded by a particular interest group,
- Unintentional errors in the research design leading to the introduction of bias,
- Errors in the execution of research e.g. uncalibrated equipment, errors in recording etc.
- Errors caused by the flawed use of indirect observation
- Errors in the analysis of results and
- Errors in the conclusions reached.

…for this reason it is important that other researchers, i.e. you, evaluate the research to confirm its validity and we will consider how to do this later in this book.

4.15 Summary

In this chapter we have learnt basic scientific principles and concepts.

We have learnt that there are two fundamental ways of collecting scientific data:-

- pure observation – in a non-invasive way
- experiment – introducing changes and observing the effects

But no matter how we do this we must follow basic scientific principles:-

- Empirical
- Measurement
- Non Invasive
- Objectivity
- Repeatability

We have learnt that a hypothesis can be tested by:-

- Conducting a controlled experiment.
- Implementing a solution and testing this solution.
- Making a prediction based on the hypothesis and testing this prediction by collecting evidence that will prove or disprove the prediction.
- Provide a mathematical or other formal proof

We have loosely categorised research projects as:-

- Theoretical or Basic Research
- Experimental Research
- Survey Based Research
- Action Based Research
- Strategy Based Research

And we have looked at two important principles:-

- Data, or unexplained phenomena, used to generate a hypothesis cannot be used to verify the hypothesis.
- Testing the Null Hypothesis often provides stronger evidence than by testing the hypothesis.

Finally we have seen that research can be flawed and thus we need to evaluate the research…

- Double blind trials should be used where appropriate to avoid the introduction of bias.
- In comparative experiments researchers must take care to ensure the uncontrollable differences are as small as possible and do not influence the results.
- Direct measurements are not always possible but indirect measurements must be used with caution.
- Data collection and recording must be accurate

Flawed research and the process of evaluation is a topic we will return to.

5 Analysing the Contents of a Research Paper

Introduction

Before you can develop the skills needed to analyse and evaluate research papers you need to understand the structure and contents of research papers thus in this chapter you will be looking at real research papers – but you won't be asked to read them word by word.

You will also learn that some research papers are different and not really appropriate for your needs. Learning how to spot these quickly will allow you to bin inappropriate research papers and replace them with alternatives and this will improve the quality of your literature search and thus improve the quality of your research paper.

In order to develop these skills this chapter includes direct links to research papers. These should either open up within a web browser or directly download a research paper as a pdf file. If a link does not open the paper it may be because of your browser security settings in which case you can try copying the link into a different browser.

In a worst case scenario a university librarian will be able to obtain a printed version of the papers.

Objectives

By the end of this chapter you will be able to…

- Understand that we are capable of dealing with scary research papers
- Understand the structure of a research paper
- Identify the hypothesis or theory being tested
- Identify the practical work reported
- Identify the analysis of results and the claims researchers make
- Recognise qualitative and qualitative research in action
- Recognise the difference between fundamental or applied research
- Classify research as Experimental, Survey based or Action research
- Understand the different ways researchers can verify their hypothesis

You will also develop one additional and important skill. You will learn how to quickly spot and identify research papers that, while valid and important, are not useful for someone wanting to evaluate research. Learning how to spot and reject papers such as these will improve your literature search and thus improve your research paper.

Developing these practical skills will help you to understand and evaluate other research papers but this requires time and effort and you are therefore encouraged to attempt all of the practical activities in this chapter.

This chapter consists of 3 sections:-

1) Understanding What a Research Paper Looks Like
2) Not All Research Papers Are The Same…
3) Summary

5.1 Understanding What a Research Paper Looks Like

To understand what a research paper looks like we need to look at a few. The papers we will use will be on diverse topics but it is unlikely that any of these topics will be familiar to you.

It is important to remember when looking at these that they were not written for students – they were written for other researchers and professional working in the field. They therefore won't include basic introductions or explanations and they won't define basic terminology. Instead they will use subject specific terminology that other professionals working in that field would be expected to understand…

and they will look scary!

But don't let this worry you or stop you from trying to participate in the activities that follow.

Without understanding the terminology or the topic it is possible to understand the research undertaken and to assess the validity of this work. Though in this chapter we won't consider issues of evaluation or validity we will just focus on understanding what the researcher(s) did.

5.1.1 Paper 1) Testing Chemical Reactions

Activity 1

In 2014 Tobias Schwabe wrote a research paper entitled:-

'An isomeric reaction benchmark set to test if the performance of state-of-the-art density functionals can be regarded as independent of the external potential'

This was published in the journal of 'Physical Chemistry Chemical Physics', Volume 16 pages 14559–14567.

The journal of 'Physical Chemistry Chemical Physics' is sometimes abbreviated as 'Phys. Chem. Chem. Phys.' or 'PCCP' and is published by the Royal Society of Chemistry.

Read the title of this paper, given above, to see if you can understand what this research paper is trying to describe.

Feedback 1

This title is probably scary. It uses lots of technical terminology e.g. 'isomeric reaction benchmark' and 'density functionals' that the writer may expect other professionals to understand but is clearly was not written for students… and is especially not intended for you if you are not studying advanced chemistry.

But still if we look at this paper a little less deeply and remove the terminology we could see this as…

'Something to test if something is independent of something else'.

Looking at this we can see that:-

a. this is indeed about research i.e. the researcher is trying to push forward the boundaries of knowledge and
b. they are testing something and this test will probably involve either a controlled laboratory experiment or a real world experiment (my guess is that it will not be a real world test as the title does not imply the application of the theory).

Hopefully from the exercise above you can see that while research papers are scary and complex we can still look at them to consider what research work is being described in the paper and we can then begin to consider how the research was conducted and if the researcher's conclusions are valid.

We developed out understanding of a research methodology in the last chapter and this is summarised as:-

- Analyse the problem
- Find out what current researchers propose.
- Develop the hypothesis
- Test this hypothesis by either
  - Conducting a controlled experiment.
  - Implementing a solution and testing this solution in the real world.
  - Making a prediction based on the hypothesis and testing this prediction by collecting evidence that will prove or disprove the prediction.
  - Provide a mathematical or other formal proof.
- Reach conclusions about the validity or otherwise of the hypothesis and make claims accordingly.

We also said that one important scientific principle is that others have enough information to repeat our experiments. Therefore research papers should clearly describe:-

- The hypothesis or theory being tested,
- The details of the tests conducted and the results with enough clarity and detail that others can follow and repeat the work.
- The results and any analysis/interpretation of these.
- The conclusions regarding the validity of the hypothesis.

Activity 2

The paper described in the previous activity can be downloaded as a pdf document, nicely presented in 2 column format, via the following link:-
http://pubs.rsc.org/en/content/articlepdf/2014/CP/C4CP00772G

and a version can also be viewed in a web browser via:-
http://pubs.rsc.org/en/content/articlehtml/2014/cp/c4cp00772g

Download this paper and skim read it to answer the questions below. Don't worry about any of the detail or terminology and don't try to understand the contents – just try to answer the questions below.

a. Can you find the abstract and do you think this summarises the contents of the whole paper?
b. Does the paper describes the problem and the claims made by other researchers?
c. What is the hypothesis or the theory being tested?
d. Can you identify the practical work done i.e. what tests were conducted and how they were conducted?
e. Can you identify the results and any analysis of these?
f. Can you identify the claims regarding the validity of the hypothesis?
g. Finally can you classify this work as quantitative or qualitative/theoretical or applied?

Remember theoretical research is research that is being done to understand fundamental principles or phenomena. Applied research try's to solve practical problems. Quantitative research is where we can take numerical measurements and process the results numerically. Qualitative research is where there are no clear measurements or numbers.

Feedback 2

Many research papers will follow a similar format to this paper though the specific headings will vary and not all papers are as clearly structured and well written as this paper is.

Without worrying about the specifics of the subject you will hopefully have been able to identify different sections of the paper and relate these to your understanding of research methodology.

a) the abstract
Research papers start with an abstract that summarises the contents of the entire paper. This is not the same as an introduction and we will consider how to write a good abstract later in this book.

This paper has an abstract directly below the author's name. The first two sentences of this describe the issue being tested i.e. the hypothesis, though the abstract does not make a specific statement whether the hypothesis is that functional performance does depend on the elements involved or does not depend on the elements involved.

It is of course necessary for an abstract to drastically summarise and ignore detail but even in the body of the paper researchers often don't make specific statements using the words 'The hypothesis is…' No matter how this is worded it should be clear what is being tested.

The abstract goes onto summarise, using just a few words:- the experimental work conducted, the effort to reduce bias, what the data/results show and in the final sentence one of the conclusions reached from this work.

b) the problem and the claims made by other researchers?
The introduction to this paper starts by very briefly explaining two 'severe and most often discussed' limitations in our knowledge and the importance of overcoming these limitations. It goes on to mention the work of other researchers who have evaluated performance issues and developed benchmarks. This section cites numerous sources of information…some books that describe the theories and research papers describing the work undertaken by other researchers in the field.

c) the hypothesis or the theory being tested?
The introduction ends with a description of 'the present study' which explains what is being tested, an explanation of how this study was conducted and a description of the limitations of the study. This section ends with a couple of sentences describing the structure of this paper.

d) details of the practical work done i.e. what tests were conducted and how they were conducted?
Section 2 and Section 3 describe the experimental work conducted and the test data used.

e) the results and any analysis of these that was done?
Section 4 describes in detail the test results, the statistical analysis of these and explains what the results show. One important part of this discussion is the explanation of the use of SCS-MP2 as a 'reliable theoretical reference dataset' for comparison purposes. This is not quite the same as undertaking fully controlled experiment but maybe a suitable alternative given constraints of the subject being studied.

f) the claims regarding the validity of the hypothesis?

Ultimately the goal of someone tasked with writing a survey paper is not to evaluate the quality of the writing but to evaluate the conclusions, to compare methods and theories and in doing these present your own conclusions.

For now however we are looking at the contents in a very shallow way in order to understand what is reported in a good research paper.

Looking at this paper we can see that this paper clearly describes:-

- The hypothesis or theory being tested,
- The details of the tests conducted and the results with enough clarity and detail that others can repeat and evaluate this work.
- The results and the analysis and interpretation of these.
- The conclusions reached.

We can also see that the researchers have acknowledged the limitations of the study and identified further research that needs to be undertaken.

It is not a problem that the research has limitations. All research is limited by cost/time and data considerations…the only concern is do these limitations invalidate the conclusions reached?

It is extremely rare that research provides a final definitive answer and it can never claim to have answered all of the questions on a subject therefore it is good that the researchers have highlighted the limitations of this specific study and identified specific issues that further research needs to address.

5.1.2 Paper 2) A Study of Human Dynamics

Wen Dong, Bruno Lepri and Sandy Pentland wrote a paper 'Tracking Co-evolution of Behavior and Relationships with Mobile Phones' published in April 2012 in volume 17, issue 2 of Tsinghua Science and Technology, pages 136–151.

This was a longitudinal study of a population i.e. it was a study conducted over a period of time. The purpose of which was to understand and develop models of human interaction in order to predict and shape behaviour.

The full paper can be downloaded from…
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6180039

Activity 3

In this exercise we are trying to enhance our understanding of the different ways research is conducted and in doing so enhance our understanding of what we read in research papers. We are not trying to understand all of the technical detail presented in this paper, or indeed any of the technical detail, so again don't worry about any of the terminology or anything you don't understand.

Download this paper, skim read it and try to answer the questions below:-

a. Can you identify what data was collected and can you classify this as quantitative or qualitative data?
b. In section 3 researchers describe a model which they say 'could capture the co-evolution' behaviour of the population being studied. Consider the very important scientific principle that data used to generate a hypothesis cannot be used to verify the hypothesis and consider how they tested this model, see section 4. Did they test the accuracy of the model proposed on a different group of people i.e. different data set or did they test this model in some different way?

Feedback 3

a. This study concerns very human issues of relationships, friendship and happiness. These are not measurable quantities and studies in this area often use questionnaires with made up scales to measure these thing e.g. 'on a scale of 1–5 how happy are you?' This would be qualitative data and is very open to personal interpretation and bias – thus large surveys are required to reduce the potential for an individual to bias the results.

   This particular study however is more specifically trying to model human dynamics and interactions that can influence issues such as friendship patterns. To do this the researchers collected specific quantifiable mobile phone data – the locations individuals visited, number of phone calls made, who was called etc and they also collected survey data which included personal information such as information about relationships and about political opinions. Thus this study involved both quantitative and qualitative data.

b. The researchers reach three major conclusions:- 1) 'relationships and behaviour co-evolve' 2) the model they developed can capture this and 3) they 'can predict friendships'.

   They didn't test the accuracy of the model proposed on a different group of people but then they didn't make specific claims about its accuracy…only that it can work. Though in order to claim the model can work it must still be tested in some way. One way of testing a theory or model is to make predictions based on the model or theory and then to test the accuracy of the predictions. This is the method employed by these researchers as report in section 4.

An interesting question does arrive here though regarding the validity of this work based on the principle that the model must be tested on data that was not used to generate the model.

A model could have been developed using just the mobile phone data and then the predictions tested using the data collected in the survey. However if the model was developed to take account of both the mobile phone data and the survey data then the survey data cannot be used to verify the model.

If we were to evaluate this paper then we would certainly need to evaluate the scientific method employed however our purpose here is not to do this but simply to understand more about the scientific process reported in the paper i.e. what sort of data was collected and how the hypothesis was tested.

Activity 4

We have previously described different categories of research, three of which are:-

- Experimental research projects which involve the investigation and evaluation of a specific technology,
- Survey Based research projects which present a survey of organisations or people, and
- Action research projects the purpose of which is to study an organisation and implement some action, i.e. to make a change, and observe results.

Look again at the same paper used in the previous exercise are try to classify this research according to the categories above. Would you classify this as experimental research, survey based research, action research or something that is a combination of different elements of these?

Feedback 4

This is clearly in part survey based research but it goes further than that. The researchers do not just analyse the survey data to reach conclusions (and then testing these conclusions on a different set of survey data). The researchers have developed and tested a computation model of human behaviour. They then evaluate this model by making and testing predictions…. This can therefore mostly be classed as an experimental research project.

An action based project would involve implementing some change to observe the impact of this change on the organisation or population being studied…for example running events to encourage specific social interactions and measuring the effect this has on friendship patterns.

This was not action based research.

When undertaking action based research the effect of the change would be measured by collecting key performance criteria before and after the change, though care would need to be taken to ensure the measured criteria are relevant… in this case we could perhaps ask the students how many friends they have.

Care would also need to be taken to ensure no other changes occurring naturally over the period of the project had an impact on the measurements. For example changes in the courses or changes in social media could also have an impact on student friendships.

The type of data collected and the experimental work undertaken by these researchers was significantly different from the work reported in the first paper. The purpose of the research dictated these differences but both papers present a clear description of the process followed, the analysis undertaken and the conclusions reached.

Understanding more about the research process will help you to understand the varying contents of the researcher papers you read and help you to evaluate the evidence and thus reach your own conclusions.

5.1.3 Paper 3) A Proposed Management Strategy

So far we have looked at an experimental study using quantitative data that investigated the fundamental nature of chemical reactions and used a 'theoretical reference dataset' in place of a controlled experiment to verify the findings. We have also looked at a longitudinal study of human dynamics that tested a model of human interaction by making and testing predictions.

In the following paper a strategy is proposed for integrating renewable energy sources within a power grid:-

Samuele Grillo, Mattia Marinelli, Stefano Massucco and Federico Silvestro, 2012, 'Optimal Management Strategy of a Battery-Based Storage System to Improve Renewable Energy Integration in Distribution Networks', IEEE Transactions On Smart Grid, volume 3, no 2, pages 950–958.

This paper is available from:-
http://orbit.dtu.dk/fedora/objects/orbit:114454/datastreams/file_10663819/content

In this paper the researchers present a mathematical model for energy storage equipment, i.e. batteries, and model the way energy is integrated i.e. sold within a national grid system. This is important research that could have a significant environmental impact. The nature of this research makes it difficult to understand and evaluate unless you have a sufficient grounding in the mathematics however as we are only looking at the research process we do not need to concern ourselves with the mathematics

Activity 5

Download the paper and look at section III, pages 954–956, and see if you can understand the general method they have used to verify the model they propose.

Feedback 5

The researchers could have implemented their model and under controlled conditions compared their model with other models, either those currently used in industry or those proposed by other researchers. However to really implement this model would have required the development of large scale, complex and very expensive electrical equipment. Not surprisingly the researchers found a different, and much, much cheaper, way to test their theories.

Instead of creating a physical implementation of their model the researchers developed a computer simulation and tested their model in this simulation. To ensure the simulation was as realistic as possible the researchers took real price, wind profile and power production data but they still needed to make several assumptions and correctly evaluate the economic gain from implementing their model.

Obviously the simulation will not be a perfect representation of the real world and testing a model or theory in a simulator is not the same as testing it under real life conditions but in many cases, especially when testing out new ideas, it makes far more sense to test ideas under simulated conditions before conducting real world tests.

If you doubt the use of simulation then ask yourself when testing new car brakes would you really like the very first test to be a real test under real world conditions? This could be an easy way to kill someone!

Unlike real world conditions, simulated conditions can also easily be replicated and this makes it easy to compare alternative theories or methods. However when evaluating research such as this we do need to consider how good and realistic the simulation is. Problems with the simulation can cast real doubt over the validity of the conclusions.

5.1.4 Paper 4) An Evolution Study

The final paper that we look at in this section has something different to offer us…

The paper below presents the results of a study of populations and their ability to withstand drastic changes in the environment. It could be of significant interest for environmentalists.

Luis-Migue Chevin and Russell Lande, 2010, 'When Do Adaptive Plasticity and Genetic Evolution Prevent Extinction Of a Density-Regulated Population?', *Evolution*, 64-4: 1143–1150 April 2010.

Available from…
http://transgenerational.zoo.cam.ac.uk/sites/default/files/Chevin%20Lande%202010%20Evolution.pdf

Activity 6

Download the paper and, without reading it, notice all of the equations on pages 1144–1148.

Next look at figure 1, page 1147, and figure 2, page 1148.

Feedback 6

This paper is a little different from the others we have looked at in the way the researchers evaluate their hypothesis.

The researchers develop a mathematic model to show how they believe a population can be resilient to drastic changes in the environment. Clearly it is not possible to test this theory out in the real world without having drastic consequences on those currently living in the world.

To test this out therefore the researchers mathematically analyse the model, see graphs 1 and 2, and discuss the implications of these findings. The researchers go on to discuss the potential for stronger evaluation by comparing the results of the model with empirical examples, i.e. make predictions using the model and test the accuracy of these predictions, but they have not yet done this.

While doing further evaluation maybe possible and desirable it is not always necessary.

It is difficult to evaluate the researchers findings unless one has sufficient mathematical knowledge however for our purposes it is sufficient to note that a mathematical proof is sometimes a better method of evaluation than a real world experiment.

Consider a real world experiment to determine the shortest route between city A and city B. A researcher could walk along all of the available roads, measuring the distance of each and show that the shorted route is the most direct route. Such an experiment would take a considerable amount of time but also is also open to error i.e. but the researcher could fail to test the best route or could incorrectly record the distance.

Alternatively a mathematician can prove the shortest distance between any two points is a direct line. Applying this mathematical proof to the problem of city A and city B we will know that the shortest route is the most direct route without having to walk up and down the roads. This will obviously save time and is applicable to any similar problem no matter what two cities are involved but also, importantly, this is less error prone than a real world experiment.

As long as the mathematical proof is valid then this is an excellent way to verify a hypothesis.

We have now looked at several research papers and how they describe evidence to support their conclusions. We have seen that this evidence can come in different forms depending upon the nature of the research. It can be:-

- A controlled experiment or a comparative study,
- Making and testing predictions based on the theory,
- Experiments in a simulated environment,
- A mathematical proof.

In addition to this, while we have not looked at a paper describing action research, we have discussed how such papers could report changes in key performance indicators and relate these changes to the action taken.

5.2 Not All Research Papers Are The Same…

So far we have looked at a range of research papers that all report some form of experimental work, results analysis and conclusions (a mathematical proof is still experimental work of a sort).

All of this work was published in reputable research sources and all of this work can be evaluated and therefore the potential exists for you to reach and present your own conclusions and thus make a valid contribution to science.

However not all 'research papers' published in reputable sources do this and while some of these are valid and published for very good reasons they are not necessarily suitable for you. In this section we will therefore briefly look at some unsuitable materials so you can learn to quickly recognise and ignore similar papers if you come across them in your literature search.

5.2.1 Paper 5) A Medical Position Statement

The paper below presents an important statement that could have serious medical implications i.e. could save lives. It was published in the Clinical Journal for Sports Medicine…and remember we are looking for reputable research papers published in journals or conferences so this is certainly a paper your literature search could throw up.

Kimberly G. Harmon, Jonathan Drezner, Matthew Gammons, Kevin Guskiewicz, Mark Halstead, Stan Herring, Jeff Kutcher, Andrea Pana, Margot Putukian, and William Roberts, 2013, 'American Medical Society for Sports Medicine Position Statement: Concussion in Sport', *Clin J Sport Med*, 23:1–18.

The paper is available from…
http://www.primarycareguidelines.com/uploads/5/8/1/0/5810751/ams_2013_concussion.pdf

Activity 7

Download the paper and skim read it and answer the questions below: -

Are the authors presenting research that they have done i.e. are they reporting any experiments, results and conclusions?

In what way does the structure of this paper differ from the other papers you have looked at?

Feedback 7

As the authors try to make clear from the title this paper does not report primary research. Instead it reports recommendations for best practice to be followed by clinicians dealing with concussion and suggests areas where more research is needed.

As you will hopefully have spotted the nature of this article is reflected in its structure as it starts with an executive summary rather than an abstract. This is one of the mechanisms used by the authors to make it clear this is not a normal research paper.

While this paper does not report primary research it may still make a very valid contribution to society and it is still very valid to report recommendations like this in journals. Not only can this shape future research but current clinicians, who read journals to keep up to date with evolving theory, can learn from the reported best practice and thus this paper can save lives.

However the lesson to be learnt here is that not all articles published in reputable journals report primary research and while they still serve valuable and legitimate functions they are not useful to a researcher who wants to evaluate current research.

Papers that are not appropriate for our needs can often be dismissed quickly by scanning the contents before wasting time reading them carefully.

5.2.2 Paper 6) A Study of Patient-Clinician Communication

The paper below is another example of a paper that is not appropriate for our needs despite being published in a very reputable source.

Liesbeth M. van Vliet, Andrew S. Epstein, 2014, 'Current State of the Art and Science of Patient-Clinician Communication in Progressive Disease: Patients' Need to Know and Need to Feel Known', *Journal of Clinical Oncology*, volume 32, no. 31, pages 3474–3478.

http://jco.ascopubs.org/content/32/31/3474.full.pdf

Activity 8

Download the paper and skim read it and answer the questions below:-

Are the authors presenting research that they have done i.e. are they reporting their own experiments results and conclusions?

When it cites other research papers are these mostly in the beginning or are the citation all the way through?

Do the researchers present their own conclusions?

Feedback 8

This paper does not report primary research, experiments and results, undertaken by the authors. Instead it cites and discusses research done by numerous other researchers and citations pointing to these papers exist throughout the whole paper.

This paper does present conclusions, on the very first page the researchers propose that two models, if integrated, have the potential to meet patient's needs. As such this paper makes a valid contribution to knowledge but these conclusions come from reasoned argument and from evaluating the work of all the other researchers. The proposal to combine the two models is not yet tested.

In many ways this is a classic survey paper – much like the one you may have to write. It reaches conclusions by evaluating, comparing and considering the potential to integrate the work of diverse other researchers.

All this can be very good and very useful. Papers such as this often help to verify the work of other researchers and suggest directions for further research. They are also often useful to give novice researchers an overview and understanding of research being conducted around the subject – not by one researcher but by numerous researchers.

However survey papers are not very useful for other researchers wanting to write their own survey paper for two reasons…1) they don't present sufficient detail of the source materials so you can't evaluate the evidence for yourself 2) the survey paper has already compared the other research proposals and reached conclusions based on this – this will make it difficult for you to generate your own unprejudiced comparison.

5.2.3 Paper 7) An Ethical Discussion

The final paper we will look at in this chapter could be characterised as an ethical discussion.

James Noland and Robert Phillips, 2010, 'Stakeholder Engagement, Discourse Ethics and Strategic Management', *International Journal of Management Reviews*, issue 279, pages 39–49.

This is available from…
http://www.researchgate.net/profile/Robert_Phillips7/publication/228118693_Stakeholder_Engagement_Discourse_Ethics_and_Strategic_Management/links/0046351ded3ace68c1000000.pdf

Activity 9

Download the paper and skim read it and answer the questions below:-

Are the authors presenting research that they have done i.e. are they reporting their own experiments results and conclusions?

Do the researchers present their own conclusions?

Feedback 9

Much like the two other papers we have looked in this section, this paper does not report primary research. Instead it cites and discusses what the authors consider as two prominent trends in recent research literature.

Based on this the authors present an argued principled position and this could usefully influence other researchers and professionals working in this area. However as this does not present a description of primary research it is not useful for someone wanting to write a survey paper.

While not useful for our purposes all three papers presented here reach argued and potentially useful conclusions. All of them were published for good and valid reasons and none of them pretended to present a description of primary research.

Still, while they may be very good, they are not really useful for someone wanting to write a survey paper and it useful to learn how to recognise these materials quickly. By avoiding them your research paper will be stronger and identifying these papers quickly will save you time.

There are other research papers that we may not consider so favourably – where conclusions should be justified by more than good arguments. For example some research papers present 'improved management strategies' where the efficacy of the proposed strategies are completely unverified. These strategies may have been developed on the basis of good arguments, and therefore sound plausible, but should they really be implemented in an organisation unless they are tested first?

Management strategies can be tested by performing action research within one small department or small section of an organisation by collecting performance data, implementing the new strategy and measuring the impact of this change. As with all action research we must take care in case other changes that occur naturally over the period of the project, e.g. a change in product lines, have an impact on the results and thus unduly influence the conclusions. This is one issue to be considered when we evaluate such research for now however the lesson is much simpler:- be aware that some research papers present claims that are unverified.

5.3 Summary

In this chapter we have looked at several research papers and seen how they describe

- The hypothesis or theory being tested,
- The details of the tests conducted and the results with enough clarity and detail that others can repeat and evaluate this work.
- The results and the analysis and interpretation of these.
- The conclusions reached.

We have seen that the research work undertaken being will be dictated by the nature of the hypothesis and practical considerations of the project and this will impact on the research process, the data collected and the methods used to verify the hypothesis. This will help you to understand the contents of the researcher papers you read and help you to evaluate the evidence.

We have seen that evidence presented to support conclusions can come in the form of:-

- A controlled experiment/or a comparative study,
- Making and testing predictions based on the theory,
- Experiments in a simulated environment,
- A mathematical or formal proof

In addition to this, while we have not looked at a paper that describes action research, we have discussed the potential evidence that could be shown when undertaking this sort of research.

The exercises in this chapter and the feedback provided were intended to help you to develop a deeper understanding of the expected structure and content of research papers.

You will also hopefully have learnt to recognise papers that, while published in reputable research sources, don't for good reason describe primary research (for example a survey paper).

While looking at these papers we have kept in mind our ultimate goal which is to reach our own conclusions by evaluating the evidence presented. While we have not yet attempted to do this we have discussed, briefly, some of the ways the evidence can be flawed. This is a topic we will return to in more depth.

6 Designing and Running Experiments

Introduction

In the previous chapter we learnt to identify the different types of work reported in research papers. While doing this we kept in mind our goal is to evaluate the evidence presented in these papers in order to decide for ourselves if the conclusions presented in these papers are valid.

To decide this we will need to evaluate:-

- the research methods,
- the discussion of results and
- the conclusions reached.

To help with this we have discussed research theory and we have looked at ways research can be conducted. In particular we have discussed:-

- Theoretical or Basic Research
- Experimental Research
- Survey Based Research
- Action Based Research
- Strategy Based Research

And we have looked at several research papers that show some of these in action.

We have also looked at methods for testing the hypothesis:-

- A controlled experiment or a comparative study,
- Making and testing predictions based on the theory,
- Experiments in a simulated environment,
- A mathematical proof.

By now hopefully you have developed your understanding of research theory and your understanding of the importance of experiments.

This chapter aims to expand your understanding of experimental design so you are better placed to understand how to evaluate the evidence presented in research papers.

We will focus on the act of critical evaluation in the next chapter.

Objectives

By the end of this chapter you will…

- Have a deeper understanding of issues regarding the design and running of an experiment.
- Be able to choose between different types of experiment,
- Have considered in detail issues regarding data collection,
- Considered how poor design can lead to errors and bias.

This chapter consists of 12 sections:-

1) What Role do Experiments Play in Research?
2) Definition of an Experiment
3) Designing an Experiment
4) Setting up an Experiment
5) Recording the Results
6) Can We Trust the Results?
7) Analysis of the Results
8) Reaching Conclusions
9) Different Types of Experiment
10) Considering Different Types of Experiment
11) More Detailed Experimental Design
12) Summary

6.1 What Role do Experiments Play in Research?

We have already touched on the idea and role of experiments but experiments are crucial to science so we will look at these more closely here. Having a slightly deeper understanding will help you to evaluate the evidence presented in research papers.

We learnt that scientific research in most cases uses the empirical method i.e. uses either data collected or data derived from experimentation. Thus the empirical method involves a hypothesis i.e. a testable claim and uses experiments and observation to verify the hypothesis

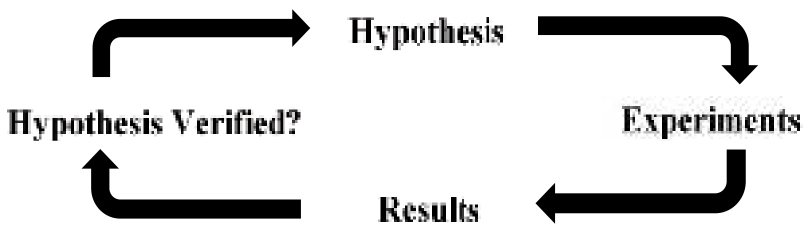
For example we may hypothesise that the use of a plant fertiliser improves plant growth. We design an experiment using two sets of equivalent plants, watered and looked after in the same way, where one set of plants is given the fertiliser and the other not. We then measure plant growth, measuring the height and width of the plants and possibly counting the number of flowers over a period of time. We can also get a group of people to visually inspect the plants in an identical manner to check leaf colour and for general signs of ill health. We compare the results to verify whether the hypothesis is correct.

In general, scientific discoveries are derived from our experiences or observations. The question is how do we collect valid observations?

In most cases we cannot get observations without any intervention as we need to set up and conduct an experiment. We collect data from the experiment in a systematic way.

Sometimes we may get these observations without intervention, we just need to carry out a skilful and meticulous data collection. We could for example survey the population to collect data about eating, exercise habits and educations levels and relate this to health outcomes. This is also an experiment. When we collect data such as this we need to collect enough data from a varied population to ensure that other factors, that we may not have considered, do not skew the results.

Verifying, or failing to verify, a hypothesis could lead us on to other unanswered questions i.e. a new hypothesis and so the cycle repeats itself.



6.2 Definition of an Experiment

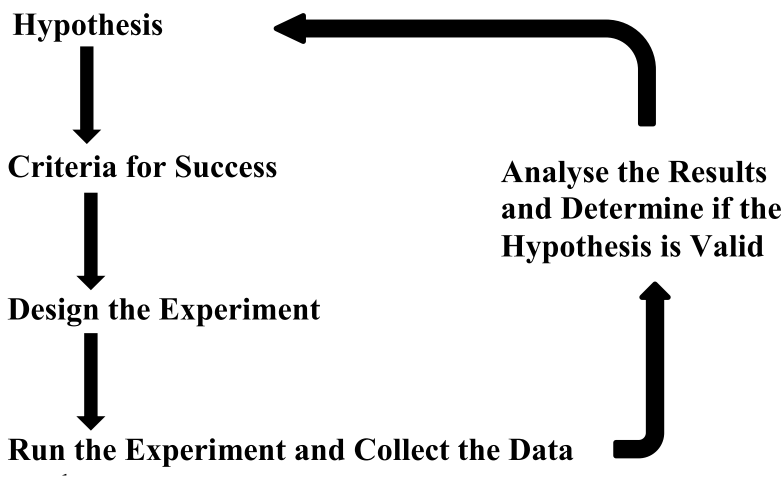
An experiment is therefore a systematic test of the hypothesis. The hypothesis is at the centre of a piece of research and needs to be verified (is it true or false?).

As such the experiment and the results produced by them have to be valid, repeatable and significant.

- Valid means that the experiment will actually test the hypothesis and the results will not be influenced by something else. For example if we hypothesise that the average role on a 6 sided dice is 3.5, i.e (1+2+3+4+5,+6)/6, we want to be sure that the dice is not weighted or thrown in a way that changes the result. If we made a mistake in our experimental design and allowed a magician to roll the dice then the test could actually be a measure of a magician's skill i.e. how good are they at palming and changing the result of a dice?
- Repeatable means that we will get the same results more or less every time we run the experiment. If for an experiment we role a 6 sided dice 100 times and repeat this experiment, the second time we do this we won't get the same sequence of numbers but the average role will be very, very similar.
- Significant means that the result is not just marginal i.e. if on the 2nd time we run this experiment we are lucky and get a few higher numbers this should have a very limited impact on the overall average. If the average did change then we would want to know why. If we designed this experiment badly so that we only rolled 2 dice, random chance could have a much greater impact on the average number rolled. Thus a change in average would tell us very little – it would not be a significant result.

6.3 Designing an Experiment

To design an experiment we need to consider on what basis would we be confident of accepting or rejecting the hypothesis? This will define the criteria for success. The experiment or test must be designed properly to provide the required data. After running the experiment the results can then be analysed to determine if this criteria has been met i.e. if the hypothesis is valid or not. On the basis of this we will make claims for new knowledge…but will our claims be valid?



The experiment itself can be carried out in different environments:- in a special test facility/laboratory, in the natural context or using a computer simulation.

To ensure our claims are valid the design and execution of the experiment must be rigorous.

Experiments are often done many times to guarantee that what you observe is reproducible, or to obtain an average result.

Reproducibility is a crucial requirement. Good science requires that others can evaluate our research and should be able to reproduce our results so accurate reporting is essential. Without this why should other researchers trust our results and trust our claims?

At the heart of our experiments is data measurement. We need to be sure we are measuring the right things, taking accurate measurements and accurately recording the results.

We need to ensure bias of any kind is avoided. We need to consider what peripheral influences can affect the outcome. Could human perceptions bias the data collection? Could errors with the equipment introduce faults?

6.4 Setting up an Experiment

To successfully run an experiment take care and preparation.

The experiments needs to be set up. Make a list of the things you need to do the experiment and prepare them. To carry out the experiment may require:-

- the generation of an artefact, e.g. a car or a computer program, that you plan to test.
- Questionnaires used to collect data – these can be tested on a small user group to ensure the questions are unbiased and understood by the recipients. If respondents misinterpret your questions then you will not collect accurate data.
- Forms may be needed to record data.
- Instructions maybe required for any personnel collected data on your behalf.
- Computers, laboratory or other specific equipment may need to be set up and tested – flawed equipment will give you flawed data.

All these need to be prepared and tested to ensure everything works before you start.

6.5 Recording the Results

When doing experiments all measurements and data have to be recorded systematically, meticulously and without prejudice…Data that you don't like it still valid data.

Experiments may not happen exactly as expected and it is vital to record any coincidental observations as well.

Sometimes things go wrong and you may have to check the equipment and restart the experiment. You may even need to go back to the beginning and redesign the experiment from scratch.

6.6 Can We Trust the Results?

We always need to assess the quality of our results and we may have detected some unexpected results to think about.

If you did not observe a consistent, reproducible trend in your series of experimental runs there may be experimental errors.

We may need to check how we carry out our measurements. Is the measurement method questionable or unreliable? Are the instruments working well and are they calibrated?

If we suspect experimental errors we need to rethink the design of our experiment

- Review each step of the procedure to find sources of error.
- Compare with results of other researchers in the literature. If your results disagree with the work of other researchers it could be that you are right and they are wrong but it could also be that you have made a mistake…so before you publish your data, analysis and conclusions check you research first!
- If possible, have a scientist review the procedure with you.

Research can be a difficult, messy process that requires objectivity, i.e. a lack of bias on behalf of the experimenter, and a willingness to restart and try again.

6.7 Analysis of the Results

Summarize what happened (using tables/graphs or written statements) and determine if the result is 'statistically significant' i.e. if it is unlikely to have occurred by chance. Statistical tests can measure significance though there is controversy in their use.

Sometimes the results can be expressed in mathematical equations and these equations may allow us to make predictions. We can then perform additional experiments to prove these predications are accurate… giving us more evidence our hypothesis is sound.

Studying the tables and graphs, we can see trends that tell us how different variables affected the observed effects. Based on these trends, we can draw conclusions.

6.8 Reaching Conclusions

In reaching conclusions we are trying to answer our original question i.e. was the hypothesis correct?

Ideally the conclusions we reach will absolutely confirm or refute our original hypothesis but this is not always the case. If our hypothesis fails i.e. if we had a theory and this is proven to be false it does not mean our research has failed. **This is still success!**

A disproven hypothesis still pushes forward the boundaries of knowledge. Knowing what did not cause the original observation allows us to consider other causes.

As Thomas Edison reportedly said when trying to make a lightbulb ‘I have not failed. I've just found 10,000 ways that won't work'…in effect he has learnt from each failure.

If we can't prove or disprove our hypothesis it is perfectly valid to make weaker claims, e.g. 'A seems to cause B', this may then require further research to prove or disprove this claim.

We need to consider:-

- If we need to do more work and more experiments to get better results?
- If your hypothesis is not correct, what could be the answer to our question?
- Were there any difficulties or problems doing the experiment and could we be detecting experimental errors?
- Do we need to change the procedure and repeat the experiment and what should be done differently next time?
- Finally what can we say retrospectively about the validity, repeatability and significance of our results?

6.9 Different Types of Experiment

What we need to evaluate and how depends on the nature of the research problem and a number of different types of experiments that we have already considered but here we will discuss them in a little more detail:-

- Controlled experiments – where a hypothesis is tested in a laboratory environment to evaluate the effect of a specific variable.
- Natural experiments – where a set of tests are performed outside the laboratory in situ in the natural setting by collecting data that show variation of a specific factor and observing its effects.
- Case Studies – which carry out a longitudinal in-depth study on a phenomenon or organisation without intervention to gain better insight into it.
- Action Research – where a phenomenon, population or organisation is studied much like a case study but with intervention to attempt to resolve a problem and observing the effects of the interventions.

There are countless variants and combinations of these that have been used and of course we have as one alternative a 'mathematical proof'.

6.9.1 Controlled Experiments

A reliable experiment should have some form of control. A control is a neutral reference point for comparison and it allows to observe what actual effect changing a single variable has.

Establishing a control requires an additional experiment but where no experimental variables are changed apart from the one variable we are testing.

If several variables are changing each time we run an experiment then we cannot be sure which is causing a change in the results. Furthermore other experimental conditions could change and these could have an impact on the results – we may not have even considered these other factors as relevant.

Without a control you cannot be sure that changing the variable causes your observations.

Controlled experiments are generally preferred because we can be sure to exclude spurious factors influencing the outcome.

When undertaking a controlled experiment we run the experiment twice. Between the two experiments all of the factors should be kept constant and apart from the one factor we are interested in i.e. in all but one thing the two experiments should be identical.

These experiments can show a causal relationship i.e. once the cause is present the effect can be observed.

6.9.2 Experiments in an Imperfect World

In the work done by Tobias Schwabe (2014), the first research paper we looked at in the previous chapter, we can see that this was not an ideal controlled experiment but instead they used a 'reliable theoretical reference dataset'.

It is easy to criticise research that does not have a perfect design however this would be unfair. Real world constraints often mean that:-

- we don't have as much data as we would like or
- we can't do a fully controlled experiment or
- some other aspect of the experimental design is not ideal.

It could well be that other researchers have used a particular dataset in their experiment and we want to use the same dataset so that we can compare our results with their results…but what if we can't run the same experiment in exactly the same way because the previous researchers didn't give us quite enough information to do so? Despite this we may still want to try and compare our methods with their methods under as closely controlled conditions as possible.

When experimental design is compromised it does cast some doubt over the results and conclusions but we need to be more intelligent than just reject research that is not ideal otherwise we would reject many research conclusions that are perfectly valid.

In the case of the research by Tobias Schwabe (2014) we must ask what if any impact did the use of the 'theoretical reference dataset' have on the results and conclusions?

When this research is properly evaluated we may believe the conclusions are fully justified by the evidence despite it not being a fully controlled experiment.

Activity 1

Consider the following experimental design:-

Researchers want to undertake a 'controlled' experiment to compare exam results between two different methods of educating children. They take two inner city schools where children are from the same socio-economic background. They therefore try to ensure the children are from equivalent backgrounds with equivalent education attainment and equivalent aspirations. They also ensure the two schools are equivalent in terms of the educational resources per child etc. Of course the researchers ensure the students are taking the same exams otherwise how can they compare results? They compare the results from one class educated in a normal way with one class educated using the new method.

Now answer the questions below:-

a. Is this a fully controlled experiment or can you think of any spurious factors that could influence the results?
b. Should we just simply reject any conclusions coming from research not done under strictly controlled conditions?
c. Can you think of one way to improve the experimental design and thus gain more accurate results?

Feedback 1

a. This is not a fully controlled experiment and numerous factors could influence the result. Firstly the teacher using the new method could work harder knowing that their class results are being observed. If the children know that they are part of a research study then they could also behave differently…if there is a reduction in truancy this could certainly have an impact on the results. The two teachers could themselves be of different standards though if the results from previous cohorts are very similar this is presumably not the case.

   If the exam results are marked by the teachers themselves this could certainly introduce bias.

   Other spurious factors could influence the results. Perhaps one class took their exam in the morning when some of the students were still sleepy. If the other class took the exam in the afternoon this difference alone could influence the results.

b. We can't simply reject conclusions from research not done under strictly controlled conditions. As you will see from looking at the other experimental types there are many situations where we cannot undertake strictly controlled experiments.

c. There are obvious things that can be done to improve the design of the experiment above:-

   Firstly we should remove the obvious cause for bias caused by treating the two classes differently. Ideally neither teachers nor students would know about the experiment thus their behaviour would not change. Of course not informing the children and their parents would have ethical implications but there are ways of getting informed consent without unduly altering the class behaviour. We could ask all parents in both schools to provide consent for the study without identifying the specific classes involved thus not unduly influencing the children of one of the classes.

   Secondly while we cannot rule out spurious influences on the results we can reduce the impact of these by comparing 5 different classes using the new method with 5 classes using the traditional teaching method…of course this has cost and time implications and we need to ask 'How many classes are enough?'.

   If the researchers had collected data from 10 classes we could always ask for more…Asking for more data is not always reasonable.

Perfectly undertaken controlled experiments are in many way ideal however these are often not possible and we can't just reject research not done in a perfectly controlled manner. We need to intelligently consider the causes of bad science and evaluate research accordingly. This will be the subject of the next chapter – for now we will concentrate on getting a better understanding of experimental design.

6.9.3 Natural Experiments

In many situations we must rely on Natural Experiments. Natural Experiments are those that rely solely on observations of the variables of the system under study.

They attempt to collect data for the system in such a way that contribution from all variables can be determined.

As natural experiments are uncontrolled, variables from undetected sources are neither measured nor held constant, and may produce false results.

Natural experiments are often undertaken in the social sciences. For example we may conduct a huge survey of a population to determine the causes of crime. In doing such a survey we may look at criminal activity and collect data on all of the socio economic and education history of the offenders. There are many factors that can influence an individual's criminal behaviour – some of which we may have considered, e.g. parental behaviour, but much of which we may not have considered or which we may not be able to collect data on e.g. opportunities for easy criminal activity and perceived gain or a particular one off event, e.g. a riot, that had unusual causes.

Determining the causes of crime is of course an important question that could influence governmental, educational and policing policy and could have a significant impact on society however we must be sure that the causes identified from the research are indeed the true causes and not mistaken conclusions caused by errors in our data collection.

To reduce/eliminate the impact of spurious factors that could influence the results any survey must be detailed and undertaken from a large and varied population. We must do our best to ensure the data collected is not biased or flawed by badly worded questions. Statistical analysis must then be done with great care to ensure the influence of each of the factors is correctly identified.

Finally care must be taken to ensure that the researchers don't assume a causal relationship exists just because there is a correlation between the measurements and the outcomes.

A trivial example of a correlation but not a causal relationship is at the end of a journey. I get off the train at the last stop and so does everyone else…these two things are strongly related i.e. there is a strong correlation between when I get off and when other passengers get off the train but the relationship is not causal i.e. it is not me leaving the train that causes other passenger to leave (I am not quite that popular ☺).

Natural experiments often highlight correlated factors, e.g. educational attainment and crime, but it would be a mistake to assume all of these are causal relationships. If the relationship is not a causal relationship improving educational standards may not reduce crime. Further work must therefore often be done to test if relationship is causal.

Despite the care needed when undertaking natural experiments they are not inferior to controlled experiments. There are often situations where they are necessary but they must be undertaken with due care and again the method and results must be open to evaluation by other researchers.

6.9.4 Case Study

A case study is a detailed and careful study of one group or one entity. It could be a study of one organisation, e. g. one business, or a smaller study of one department.

Case studies are often done where researchers are trying to understand one aspect of an organisation. As no two organisations are identical it is often not possible to have a control so, as with a natural experiment, we need to be careful other factors are not influencing our results.

If the study is of one department it could be possible to compare this with another department but unless these are identical in all aspects this would not be a perfect controlled group.

Unlike a natural experiment, which may use a survey to collect a small amount of data from a large population, a case study will investigate one organisation in depth. It may involve a longitudinal study i.e. be done over a period of time.

Often case studies are undertaken when researchers do not want to perform a specific experiment or test but solely gain a better understanding of a domain or phenomenon. These are often undertaken in social sciences but can be used in many other fields as well.

Case studies therefore involve an in-depth, longitudinal examination of a single domain or event. They are based on a systematic way of looking at events, collecting data, analysing information, and reporting the results. As a result the researcher may gain a sharpened understanding of the phenomenon, or a process.

Case studies can be used to investigate/test a hypotheses but the observations made can often generate a new hypothesis that then needs further testing.

For example an organisation may notice that they are getting a very low number of repeat customers but they may not know why this is the case. There could be numerous causes…poor products, poor service or something else. But if it is poor service what aspect of the organisation is causing this?

A case study may collect all sorts of details about the processes involved in the organisation and the service offered to customers. Careful analysis of the data may highlight a clear cause however the results may not be clear cut. It may be clear that customers are getting a slow response to product queries but is this really the cause of low levels of repeat business?

If this is the belief this then becomes a hypothesis that could be tested by further research and one way of doing this is by undertaking action research.

6.9.5 Action Research

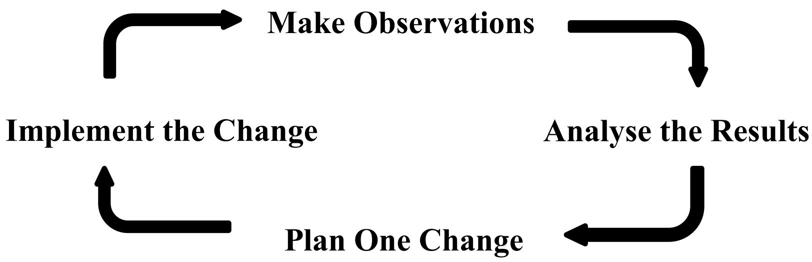
Action research is a spiral process which allows action (change/improvement) and research to be achieved at the same time.

One example of action research would be to collect data from the organisation showing the response times for customer queries and levels of repeat business, make changes to improve the response times and measure the data to see if response times have improved and see if there is a measured impact on repeat levels of business.

Understanding an organisation, possibly by undertaking a case study first, allows us to make a more intelligent well informed change. At the same time making this change and collecting the resultant data allows us to confirm or refute our hypothesis thus we learn more about the organisation by seeing what impact, if any, the change had.

Making changes to an organisation, processes etc affects the staff involved and this requires care. If the people affected by the change are involved in the action research they may be more willing to support the changes.

An action research study can begin with an imprecise research question. Initially imprecise questions and methods can be expected to yield imprecise answers but these answers can help to refine questions and methods and lead to more precise actions and a better understanding of the organisation. Thus the process can be cyclical.



If multiple changes are made at the same time it will be very difficult to determine the impact of an individual change. Therefore when undertaking action research only one change should be made at a time.

As with a natural experiment and a case study we must take care of confounding issues i.e. of other factors that may influence the results. As action research takes time other factors within the organisation are likely to change while the action research is being undertaken and these may have an impact on the results and the conclusions we reach.

Imagine customer response times are significantly improved but there is no change in repeat business. Is this because customer response times were not the cause a low levels of repeat business or could something else have deteriorated while we made changes to improve response times? If, at the same time as we improved the response time, the quality of the response became worse it will not be surprising that the level of repeat business did not improve. However if we are not aware that the quality of the response has deteriorated we could reach the erroneous conclusion that the response time did not matter.

As with all research we must take care to ensure the research and our conclusions are sound.

6.10 Considering Different Types of Experiment

The exercises below are designed to improve your understanding of experimental design. This will be beneficial when evaluating research others have done.

Activity 2

Assume we have a theory that eating habits of children have more impact on weight than genetics. Spend a few minutes considering how you could devise an experiment to test this theory. In particular would you use a:-
Controlled experiment
Natural experiment
Case Study or
Action Research

Feedback 2

It would be possible to devise a controlled experiment for this:- take a large group of children who are identical twins. Keeping all other factors the same vary the eating habits i.e. make one twin eat healthy food and make the other eat junk food. Finally compare the weight outcomes for the children who ate the junk food to see what impact their genes had and compare the weights of each pair of twins to see what impact their varied diet had.

This experimental design would work but this would be somewhat unethical! It would also be difficult to keep all other factors the same…children, including identical twins, can have different hobbies and therefore do different levels of exercise.

However identical twins have in the past been separated, possibly through the adoption process or for other reasons, and brought up in different families. Being in different families the different children live different lifestyles…of course exercise and eating habits would not be the only differences, but if we had enough data from enough identical twins who have been brought up separately we could then compare their weights and try to attribute these to difference's in lifestyles…exercise, eating habits etc we could therefore assess the impact genetics had and compare this with the impact diet had.

Researchers have in fact collected data on many such twins as this makes it easy to study nature verses nurture issues.

Going back to our problem we could actually do exactly the same comparison within the general population…we don't need identical twins for this. Of course we would need to collect genetic data, i.e. take a blood sample, as well as collecting survey data and we would need a large data set to determine the effect of genetics vs eating habits while eliminating other lifestyle issues that effect weight. This would not be a controlled experiment as there is no control group – it would be a natural experiment as it relies solely on collecting data from the population without making any changes.

A case study is not appropriate here as we are not investigating one organisation but action research is possible (though not easy). We could encourage a change in the eating habits of the population in one city and see what impact this has. Of course we would still need to collect genetic data for comparison purposes and rule out other factors and it is not easy to change the eating habits of an entire city. We could take a smaller group and try to change the eating habits of children in one school. While not easy this would be possible with concerted effort and would have the advantage of improving the health of those children at the same time.

Both natural experiments and action research are therefore possible answers here.

Activity 3

Assume we have a theory that one type of engine is more fuel efficient than another. Spend a few minutes considering how you could devise an experiment test this theory. In particular would you use a:-

Controlled experiment
Natural experiment
Case Study or
Action Research

Feedback 3

It would certainly be possible to undertake a controlled experiment for this. Take the two engines and, keeping all other factors the same, compare them to see how far they will go on 1 litre of fuel. To keep all other factors the same it would be easier to run this experiment in a lab rather than in the real world.

A controlled experiment would allow us to make a clear and precise comparison however we would need to ensure that the experiment was a realistic simulation of the real world. Speed obviously has an impact on fuel efficiency and it is possible that one engine is better at slow speeds and the other at fast speeds…so we would need to run this experiment at several speeds. However other factors also have an effect in the real world:- Motorway and city driving are also different and we need to consider this if we are to make a claim that drivers would experience a better fuel efficiency with one of the engines.

We could consider a natural experiment, i.e. do a huge survey, to see which engine type is more fuel efficient in reality… but we would need to collect lots of data to eliminate differences caused by different car manufacturers, old/new cars, driving styles etc and we would need to be sure that we collected accurate data on distance travelled per litre of fuel. Not easy to do! We certainly could not rely on human memory or personal reflections and anecdotal evidence.

Case studies and action research are not at all relevant here.

A controlled experiment here would therefore certainly be the easiest way to compare engines…but we would need to be careful to ensure we don't exaggerate our claims and say the results we obtained would be an accurate reflection of the a drivers real world experience.

In the example above a controlled experiment is the ideal solution however there would be a significant complication if the two different engines required different type of fuel. We would then need to calculate the energy density of the different fuels and take this into consideration when comparing the different engines.

Complications like this are often found when designing experiments but these are often resolvable.

There is a simple alternative that we may wish to consider…. Instead of comparing engine efficiency we could compare the running cost i.e. the distance travelled per £ spent on fuel for each fuel/engine combination. This would often be reasonable as most drivers are not interested in which type of engine is more efficient, petrol or diesel. They interested in which type of car is cheaper to run (though fuel costs are of course not the only consideration here).

6.11 More Detailed Experimental Design

After deciding on the overall type of experiment we then need to decide on the details of the experiment. Exactly what will we measure i.e. what data will we collect? How will we collect this? What equipment will be needed? How will we ensure the data we collect will be accurate and free from bias? How will we analyse the results?

Activity 4

Consider the following scenario and answer the questions below:-

A car manufacturer has designed 10 different car seats and wants to know which seat design is the most comfortable.

a. What experiment would you undertake (a controlled experiment/natural experiment/case study or action research)?
b. What would you measure and does this require quantitative or qualitative data?
c. How would you run this experiment?
d. How would you collect and record the data?
e. How would you ensure a lack of bias in the results?
f. How would you analyse the results to decide which seat design was most comfortable?
g. Are there any limitations of the proposed experiment?

Feedback 4

a. What experiment would you undertake (a controlled experiment/natural experiment/case study or action research)?

This calls for a controlled experiment, run 10 times, where each different seat design is tested under the same conditions.

b. What would you measure and does this require quantitative or qualitative data?

This requires us to assess comfort which is not quantifiable so we would need to collect this qualitative data using an appropriately designed scale e.g. 1-Very Uncomfortable, 2-Uncomfortable, 3-Neutral, 4- Comfortable and 5-Very Comfortable.

c. How would you run this experiment?

We would need to run this experiment with a range of people of differing heights, differing weights and both sexes as males and females have different body shapes. We may also need to consider ethnic/cultural differences in case different cultures have different expectations of comfort – it may not seem obvious but different colours have differing impact on people brought up with different cultural expectations.

We would also need to define precisely how this experiment would be run…will each person just sit in the seat for 5 minutes or will they drive a car for an hour while sitting in the seat?

d. How would you collect and record the data?

We would need to use a carefully worded questionnaire and we would need to check the wording of this. To do this we may run the experiment on a very small scale just to check it is clear, unbiased and appropriate to what we are measuring.

e. How would you ensure a lack of bias in the results?

To reduce the potential for bias we would need to run the experiment with numerous individuals so we get an overall view and so not be unduly influenced by 1 or 2 individuals. We would need to ensure the testers are a fair representation of the population – if 55% of the population are females then 55% of the testers should be female. We also must ensure that no bias is introduced by the person running the experiment and collecting the data…thus the seat designers should not be collecting the data.

We must also consider the order effect…if the people involved in the test sit in all 10 seats starting with design 1, and working up to design 10, by the time they test the final seat they will be weary and potentially sore…thus design 10 will get poor scores when compared with design 1. This would not be a fair test.

We must therefore either vary the order seats are tested in so each design is tested first by 10% of the testers. There is actually no requirement for each tester to test each design…if we have enough testers we can just randomly allocate testers to 1 of 10 groups and get each group to test 1 design.

f. How would you analyse the results to decide which seat design was most comfortable?

To analyse the results we could just take an average score or compare graphs of the data but we should also consider statistical techniques to ensure we have used enough testers and the results are not just marginal or influenced by random chance.

g. Are there any limitations of the proposed experiment?

Finally, as we have noted, we would need to ensure the testers are a fair representation of the population…but populations are different around the world and body shape also changes slightly. Therefore the best seat design for American consumers is not necessarily the best seat design for a Japanese market.

This does not require us to collect data from testers in every country around the world but we do need to recognise this issue so our final conclusions are valid. It we have testers that are fair representative of a European market we cannot reach the conclusion that Seat X is the best for everyone.

Detailed experimental design is important if our conclusions are to be valid and we must certainly consider issues of data collection, bias and any limitations of the experiment.

6.12 Summary

In this chapter we have focused on understanding more about the design of experiments as understanding these are essential if we are to evaluate the work and conclusions of other researchers.

We have looked in detail at different types of experiments:- Controlled, Natural, Case Study and Action Research and we have considered when/where to use these.

We have seen that while controlled experiments may seem ideal the other experimental types are also required – they just need to be carefully done.

We have also seen that having a control group is not always simple but still, with care a comparative study is sometimes possible.

We have looked at experiment design in more detail and considered issues of data collection/bias and limitations.

The gold standard for any experiment is:- Repeatability, Validity , Significance and we need to consider if our experimental design meets these standards.

We need to be very meticulous when:- designing the experiment, doing the experiment, collecting and recording the data and analysing the results.

Just as we will learn to evaluate the work of other researchers so other researchers will evaluate our research.

Having now considered experimental design in some detail we will now focus our attention on how to evaluate the work of others.

7 Bad Science and the Need for Critical Evaluation

Introduction

Way back in chapter 1 we discussed how when writing a research paper you need to evaluate research and present your own conclusions. In order to help with this we have now looked at experimental design and started to consider issues of data collection/bias and the limitations of the experiments.

We saw that experiments need to be undertaken carefully and saw that doing a controlled experiment under ideal conditions is simply not always possible.

We saw that even if a perfectly controlled experiment is possible there will still be questions to answer unless the experiment is a prefect reflection of real world conditions (an unlikely circumstance).

In chapter 1 we saw that 'Critical Evaluation' does not mean finding fault. It means to judge/assess the important aspects of the work. However to do that we must have an understanding of what can go wrong in research.

The purpose of this chapter is to help you to understand that bad science does exist and help you gain an understanding of how to critically evaluate the evidence.

In particular we will consider:-

- what could go wrong with experimental methods,
- what could go wrong with the reporting of results,
- what could be wrong with the conclusions researchers reach,
- and we will consider one additional but important thought.

Objectives

By the end of this chapter you will…

- Have a deeper understanding of just what can go wrong in research
- Have a little experience of evaluating research methodology, discussion of results and researchers claims.

This chapter consists of 16 sections:-

1. Scepticism is Good and Science is Essential
2. But What about Bad Science?
3. Bad Science
4. Evaluating the Science
5. Poor Methodology…
6. Examples of Good or Bad Methodology
7. Big or Small Question Mark
8. Flawed Discussion of Results…
9. An Example Discussion of the Results
10. False Positives verses False Negatives
11. Unjustified Conclusions…
12. An Example of a Researchers Conclusions
13. Accepting Conclusions as Valid
14. Learning More about Critical Evaluation
15. One Additional Thought…
16. Summary

7.1 Scepticism is Good and Science is Essential

Politician's often quote statistical evidence to support their claims but when two politicians are arguing for opposing policies and denying the other persons statistical evidence it's hard to know who to trust. Furthermore if statistical evidence is sound you can't just deny it.

It's not surprising therefore that both politicians and statistics end up with a bad reputation.

Activity 1

Watch Michael Shermers 'Baloney Detection Kit' (14 Mins)

This is an informative and entertaining video that explains why scepticism is good and how science is essential. It also presents 10 things to consider that will help you to determine the truth from the rubbish.

https://www.youtube.com/watch?v=aNSHZG9blQQ&list=PLgPIENXhxGTQhiBxtBBuhhZTpzBukZZXa

Feedback 1

Science is the best way we have to determine the truth and being sceptical is the best defence we have against conmen, people who are biased and scientists who have made mistakes.

In many ways this book is trying to give you the skills to be a professional sceptic…a person who doesn't reject the claims of others because of their own personal prejudice but a person who accepts or rejects those claims after looking at the evidence and applying sound scientific reasoning to determine if the claims are valid.

7.2 But What about Bad Science?

While science is essential as we have seen in the video above scientists can, and do, make mistakes. Furthermore by the time science is reported in the popular press it is often exaggerated or distorted to the point where the claims made are simply not true.

Worse still are the pseudo scientists who put on the trappings of a scientist, wearing a lab coat for instance, and who report distorted claims of scientific evidence in order to give their claims false legitimacy.

Next time you see someone, in a shopping centre, wearing a lab coat while selling a new diet pill, or other health product, ask yourself 'Why do they need to wear a lab coat when selling something that is inside a sealed packet inside a box?'

Whenever claims are made we need to determine if the claims are sound and we need to understand in what ways science can be flawed in order to determine this.

Activity 2

Watch Ben Goldacre: Battling Bad Science (14 mins)

This is an informative and entertaining video that explains many ways in which scientific evidence can be distorted.

https://www.youtube.com/watch?v=h4MhbkWJzKk

Feedback 2

Understanding how science can be distorted is essential if you are to be able to evaluate the evidence presented in research papers.

Activity 3

Read the article, link provided below, 'Science is often flawed. It's time we embraced that.' by Julia Belluz and Steven Hoffman, 2015. This is a short but informative article that explains the extent of the problem with bad science, the limitations of the peer review process and highlights the extent of problem with distorted news.

The article also offers suggested solutions namely post publication review and meta research.

http://www.vox.com/2015/5/13/8591837/how-science-is-broken

Feedback 3

Ultimately science, and the claims scientists make, can be flawed and we need to apply a healthy level of scepticism to the claims made before we accept them as valid.

Writing a research paper requires a critical evaluation of the evidence but these same skills should be applied whenever you are being sold and idea or product.

We therefore need to consider:-

- What could go wrong with experimental methods?
- What could go wrong with reporting results?
- What could be wrong with the conclusions?

7.3 Bad Science

Not all science is perfectly executed.
Not all results are perfectly reported.
Sometimes conclusions are reached that are not completely justified.

Scientists sometimes make mistakes!
Sometimes people use bad science deliberately for financial reasons!

7.4 Evaluating the Science

Even if a research paper is published in a well-respected journal you should determine for yourself if the conclusions presented in the paper are valid.

To determine if the conclusions are valid you must ask the following questions…

Was the **method** used for the experiment scientifically sound? ✓ ✗

Were the **results** accurately and fairly reported? ✓ ✗

Were the **conclusions** fully justified by the evidence? ✓ ✗

If the answer to **any** of these questions is **no** then we must reject the conclusions.

If the answer to **all** of these is **yes** then we can accept conclusions as valid.

Accepting the conclusions after evaluating the method, results and claims is still critical evaluation. Remember critical evaluation does not mean **'finding fault'** it means **'assessing the quality'**.

7.5 Poor Methodology…

The first step is therefore to evaluate the research methodology and some of the potential flaws or issues with research methodology are listed here…

Confounding Variables: confounding variables can be an issue in any research where a perfectly constrained controlled experiment is not conducted. They can often be found in observational studies where some other unmeasured variable is causing an effect on the results.

Complexities with Comparative Studies: In a controlled experiment all of the variables should be perfectly controlled and the only difference is the one variable being tested. However it is not always possible to conduct a perfectly controlled experiment and in these cases researchers will sometimes do a comparative study where there are several variations between the things being compared. In such situations we need to carefully assess the detail of the comparative study to ensure that other differences between the two groups do not impact on the results. This really is another example where a problem caused by a confounding variable is possible.

Badly Randomised Groups: In a controlled experiment, where two groups of people are involved, the participants should be randomly allocated to groups. If this is not done or if the groups are randomised badly, e.g. by human selection, then the two groups will not be identical – one group could be fitter, taller etc and this could have an impact on the results.

The Order Effect: As with randomised participants the order people do activities can have an influence on the outcomes. As with the example previously mentioned where participants are used to test car seats for comfort. The order the seats are tested should be randomised or this will have an impact on the results.

The Placebo Effect: The Placebo effect is not a myth. The effect is real and it is the power of belief and of the mind. To overcome this effect a doubly blinded trail should be conducted. In a doubly blinded drug trail the patient is not informed if they are getting the real treatment or the placebo. The doctor who is administering the drug and collecting the results is also not aware which patients are in which group (this prevents the clinician from being biased in the way they talk to the patient or collect the results from the patient).

Correlation/Causal Confusion: Research that identifies a correlation between variables but then assumes that the relationship is causal link without properly confirming this (an example of this was discussed in a previous chapter).

Surrogate Outcomes: Measuring surrogate outcomes is sometimes necessary however if we are not measuring the actual outcome we wish to measure but are measuring a surrogate we must be confident that the surrogate is an adequate substitute otherwise our conclusions will be flawed (an example of this was discussed in a previous chapter).

Data Not Cleaned: Occasionally when collecting data there is an anomaly in the data. Such items of data do not represent the norm and should be removed so as not to unfairly influence the results. For example if a researcher is comparing the walking habits of male and female ramblers where almost all of the participants in the study are serious walkers, who go out on long walks 2 or 3 times per week, but where one member of the group has only just joined the group. They are new, inexperienced, not as fit as the other members of the group and don't yet have all of the normal walking gear. Their habits are likely to be very different from the norm and they should be excluded from the study. Cleansing data, i.e. removing anomalies, is important but must be done fairly so as not to introduce bias into the outcomes.

Poor Data Collection: Poor methods for data collection, e.g. machines that are not calibrated, relying on human senses, poor data recording etc, can cause errors in the data and thus errors in the experimental results. Humans can be used to collect data, e.g. to spot unusual birds, but care must be taken to ensure the data is accurate. One way of doing this is to ensure only the data that is corroborated by other observers is used.

Biased Data (Accidental): Care must be taken to ensure none of the data used in an experiment is biased. Bias can creep in from many sources:- badly worded questionnaires, human bias when asking the questions or collecting the results, biased or unrepresentative participants. For example, assume a researcher is collecting the views of a city's residents on their local city council. They stand outside the shops in the city centre early one morning and ask everyone who passes, **random strangers**, to fill in a carefully worded unbiased questionnaire. However the results of this survey will be biased as the people surveyed are not 'random'. The people who pass the shops early in the morning are likely to be people who work in the city centre and they are not truly representative of everyone living in the city. In particular people who live in the city but work outside of the city are not likely to be passing the city centre shops. These residents may have important views on issues such as transport links in the area that this survey would not collect.

Biased Data (Deliberate): All experimental results should be recorded, both positive and negative, yet some researchers have deleted the negative results and thus have presented conclusions based on a flawed set of data. There can be several reasons for doing this…a fundamental lack of understanding of research or human bias (for personal or financial reasons). Looking at one research paper and one experiment it is extremely difficult to detect if data has been falsified in this way. It is only when looking at large meta-studies that the effect becomes noticeable. When evaluating one research paper it is therefore best to assume the researcher has not falsified the data however questions of bias can be asked if the research is funded by a particular lobby or interest group.

7.6 Examples of Good or Bad Methodology

Researchers who may have made a mistakes in the way they designed and conducted some research are in many cases unaware of the problems and sadly there is never a section in a research paper called 'What is wrong with this research'.

To evaluate the problems with the methodology a reader has to carefully read and consider every step of the researcher's methodology. If a research paper is well written at least the details of the methodology should be clear but it does take time and effort. Time to read the paper carefully and effort to consider each step in the process to evaluate each step for potential flaws.

Practising your evaluation skills on real research papers would be a long and complex process and this would be especially difficult if the subject of the paper is not something you are familiar with. As this is therefore probably not the best way to get you started there are some very simple and short scenarios are presented below to give you a chance to consider issues with methodology.

As these are very short and simplified descriptions don't consider issues of missing information – just consider if there are clear problems with the methodology.

Activity 4

Consider the following research scenario below and answer the question below it:-

Many younger members of society, in particular children, have been brought up with modern technology, module phones, the internet etc, and have no problem using these technologies. However some older people have not used the internet at all and others have been known to find browsing the internet difficult. Given this a researcher wanted to know which web browser is the easiest to use for someone over 70 years old who has never used a web browser before.

Rather than ask subjective questions regarding 'ease of use' the researcher decided to quantify this. They gave the participants of the study 10 pieces of information to find and measured how long it took them to find all 10 and they measured how often the person asked for help…the theory being that if a browser was easy to use the participant would not need lots of help and would find the information quickly. A more difficult web browser would require more help and take longer to use.

The researchers made sure the participants were a fair reflection of society i.e. varying gender/educational/work experience backgrounds etc and to ensure that the results were not unduly influenced by 1 or 2 individuals the researchers used a large sample group (100 participants). On checking the researchers discovered that one of the participants had used a web browsers before. Their results were therefore excluded from the study. None of the other 99 participants had used a web browser before.

The researcher asked all of the 100 participants to use web browser A and they measured how long it took them to find the answers and how many times the participants asked for help.

After testing web browser A all participants went on to test web browser B, then C and finally D.

Look at each step of the way this research was conducted and consider if there was something wrong with the methodology. If so how could this research have been changed to fix the problem?

Feedback 4

The researchers used a reasonable sample size and ensured the participants were a representative sample of the population. They cleaned the data and correctly excluded one set of data from the results.

The researchers did not measure 'ease of use' instead they took two surrogate measures, 'time to find the answers' and 'no of times the participants asked for help'. These two were quantifiable and taken together could perhaps be a reasonable indication of 'ease of use'. This data certainly made it easy to compare the results of testing one web browser to another.

However there was one significant error in this research. None of the participants had used a web browser before they used web browser A – not surprisingly perhaps they then struggled, they took time to find the answers and asked for help numerous times.

By the time the participants came to use web browser D they had used three others, A, B and C. While this web browser interface may have looked a little different the participants had learnt from their previous experiences…they therefore did not ask for help often and found the answers quickly.

The researchers concluded that browser D was a better web browser for older novice users as it was easier to use… However this was a flawed piece of research and thus the conclusions reached are unjustified.

If you spotted this order effect error then 'Well done!'

If you think the summary above was made up and was not 'real research' then you would be wrong. This was a summary of real research that was reported as part of a larger research project. As in the summary above the research methodology followed by the researcher involved was flawed.

There is one additional point to make here…the descriptions in the original research paper were much more detailed and complex than in the summary above. Furthermore the original researcher was not aware of the methodological error they had made so the description of the error was not so glaringly reported. Therefore if a reader quickly glanced over the research paper they would perhaps not spot the error. Spotting errors like this requires an understanding of research but it also takes time and requires conscious and careful thought.

Activity 5

Consider the following research scenario then answer the questions below:-

Three friends had a dispute over the difference between caffeinated and decaffeinated coffee. One friend declared adamantly that he can always tell the difference and he doesn't like decaffeinated coffee.

The three friends decided to do a proper research study to check this assertion. They decided to conduct a doubly blind controlled experiment and to help with this they involve a fourth friend.

The fourth person ran the experiment. To do this they bought 3 lots of caffeinated coffee and 3 lots of decaffeinated coffee. To keep the coffees as similar as possible the researcher ensured that the varieties are all medium roast and cost approximately the same. None of the coffees were on sale at the time and thus hopefully the price indicated they were of similar quality. Each batch of coffee was split into 3 smaller batches, making 18 batches in total. The coffee was randomly ordered and anonymously packaged and labelled.

The three friends drank one batch of coffee each week, not knowing anything about the specific coffee they were drinking, and give it a rating 1–5 depending on how much they enjoyed the flavour. The friends also stated whether or not they thought the coffee was caffeinated or decaffeinated. Thus each type of coffee was rated 3 times by each of the 3 friends reducing the chance of random error. The results were all carefully recorded by the 3 friends.

At the end of the trial the person running the experiment analysed the results and noted that the 3 friends correctly identify the decaffeinated coffee only 47% of the time…random chance would give them a 50% success rate. He also noted that on a scale of 1–5 one of the coffees gained an average score of 4.6 significantly higher than the next best coffee (that only scored 3.5). This 'best coffee' was decaffeinated.

The results of the friend who adamantly declared that he can always tell the difference and he doesn't like decaffeinated coffee closely reflected the group results. Though he only spotted the decaffeinated coffee 44% of the time and he gave the best coffee a score of 4.7.

The researcher concluded that the group, and this friend in particular, could not tell the difference between caffeinated or decaffeinated coffee. Despite the small sample set the researcher also concluded that all of the friends clearly enjoyed some decaffeinated coffee.

a. Look at each step of the research and consider if there something wrong with the methodology.
b. Specifically now consider if the small sample size, 6 sets of coffee (3 caffeinated and 3 decaffeinated) and 3 participants in the study…was this small sample size a problem?

Feedback 5

Considering the research methodology overall this was a carefully controlled doubly blinded trail with adequate steps taken to remove the chance of bias from the participants. Care was also taken to ensure the results were properly and accurately recorded.

Steps were taken to ensure that the coffees were all generally comparable.

The results were significant. The group gained a slightly lower than average score for their ability to identify decaffeinated coffee and one of the decaffeinated brands scored a significantly higher score for flavour when compared with the others.

This was, in short, a well conducted study.

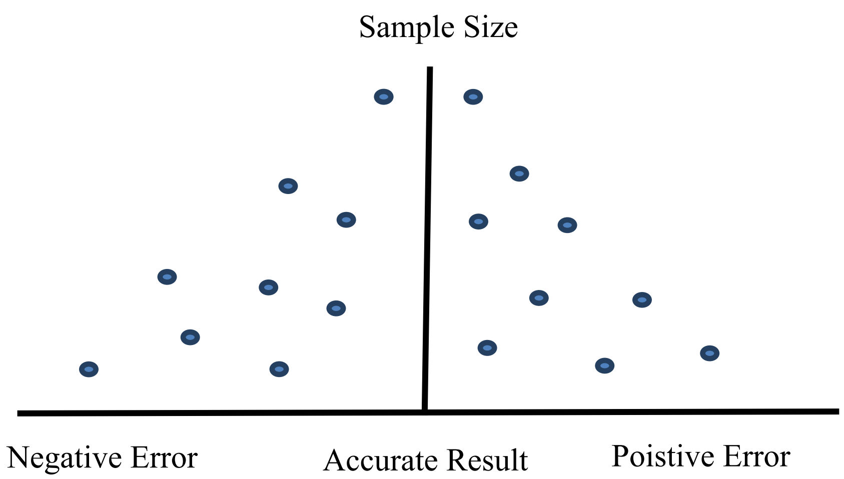
Only 3 caffeinated and 3 decaffeinated coffees were tested…and only 3 taste testers were involved.

It is always easy to criticise the sample size but what would be enough? To assess the sample size we really need to look at the researcher's conclusions.

If the researchers concluded that decaffeinated coffees were generally more flavoursome than caffeinated varieties then it would be reasonable to criticise the samples used in this study. Three friends do not sufficiently represent the population of people buying coffee and three samples of caffeinated coffee, all within one price bracket, do not adequately represent all of the varieties of coffee available.

However looking at the specific conclusions reached the sample size in this study was not a problem. The conclusions reached were that this group could not tell whether coffee was caffeinated of not…and every member of the group, i.e. 100%, were involved in the tests. The researcher also concluded that 'all of the friends clearly enjoyed some decaffeinated coffee'. To reach this conclusion only required one flavour of decaffeinated coffee to score well and the coffee that scored the best was decaffeinated. Thus this conclusion was justified despite the small number of coffees sampled.

When considering experimental methods it should be noted that experiments with small samples can have larger, positive or negative, errors due to random chance and these errors will reduce as larger studies are conducted. In other words larger studies are more likely to give you a more accurate results (see sample error plot diagram below).



Despite this initial studies are often done with small samples and this is fine if the conclusions reached reflect this.

7.7 Big or Small Question Mark ? or ?

Good science should be repeatable by other researchers. Thus when evaluating a researchers methodology a valid question to ask is 'Has the experimental method been reported in enough detail so that other researchers can repeat the experiment?'

The answer to this question should be **yes** however if the answer is **no** this does not prove the research methodology was flawed.

If when looking at the experimental method you can clearly identify flaws, for example bias in the data, then there is a **huge** question mark over the validity of the conclusions. You can't be certain the conclusions are not correct but you certainly cannot be confident they are valid. Hence the huge question mark!

However if some detail is missing from the description this is not the same as clearly identifying an error. Researchers should report all important aspect of their work including, where relevant, how the participants were randomly allocated to groups. However failure to report this does not mean the participant were not randomly allocated. Failure to report some detail such as this can lead us to have small doubts over the validity of the conclusions but this is not the same as identifying clear flaws in the methodology.

There is also a difference here regarding journals papers or conference papers. Journal papers can often be larger than conference papers – sometimes 30 or 40 pages long. When papers are this long then there is no excuse for not properly reporting the details of the research.

Conference papers, by comparison, are often shorter. In some cases they are very short. Some conferences limit the length of research papers to 6 sides or less. When a researcher has such a severe limit on the word length of their paper they will unavoidably reduce the level of detail in their reporting and thus some important detail may be missing.

Missing out this detail in these circumstances is unavoidable and while this may lead to some small questions over the validity of the conclusions the researcher should not be unduly criticised.

7.8 Flawed Discussion of Results…

If flaws are found when evaluating the experimental methodology, and this includes flaws in the analysis of the data, we can immediately reject the conclusions however if the methodology is sound the discussion of the results could still be flawed as negative aspects of the results could be ignored.

7.9 An Example Discussion of the Results

Activity 6

Consider the research scenario below and decide if the claims made regarding what the results show is fair.

Previous researchers have developed automatic stopping systems for cars. Cameras in the car are connected to computers and these use vision recognition to detect if a child is crossing the road. If a child is detected the car will automatically brake.

For obvious reasons the system was tested in a laboratory, under a range of test conditions, and the researchers measured the accuracy of detection and detection speed. Current detection accuracy is 98% and the detection speed is 0.1 second.

Obviously a detection rate of 98% is not perfect but then a 100% detection rate is not likely to be possible. Furthermore to save lives a system does not need to be perfect. For a driverless car it just needs to be better than a human driver.

Despite this other researchers wanting to improve on this work developed a new system. They tested this under identical conditions in the same lab and found that the new system has an accuracy of 99.99% but a slower detection speed of 1 second.

The researchers state that the results show the new method is more accurate than the old method.

Is this a fair and accurate discussion of the results?

Feedback 6

The researchers are correct in stating that the new method is 'more accurate' but this is not a fair discussion/reflection of the results. The new method also has a slower detection speed and in a real system detection speed would be critical for safety.

Researchers have a reason to be biased and make their research sound more impressive than it really is. The more impressive their research is the more they are likely to gain recognition for their work and the more likely they are to gain funding for further research.

Researchers may therefore overlook the limitations of their results and this can lead to unjustified conclusions.

7.10 False Positives verses False Negatives

Activity 7

Consider another scenario.

A burglar alarm is created that detects most burglars but has a false negative rate of 5%…in other words it detects 95% of burglars but fails to detect the other 5%.

The alarm also has a false positive rate of 0.5%…in other words 0.5% of the time, when people pass the house the alarm goes off incorrectly.

In order to catch more burglars researchers trying to improve the system and create a new alarm which has a false negative rate to only 0.1%. In other words the new system will now catch 99.9% of burglars…this is much improved over the previous detection rate of 95%. As the new alarm is more sensitive the false positive rate is also increased however. This goes up from 0.5% to 3%.

The researchers state that that despite the increased false positive rate these results show a much improved alarm as it will now detect 99.9% of burglars and this is a significant increase in the old detection rate of 95%.

Is this a fair and accurate discussion of the results?

Feedback 7

To determine if the new alarm is better or worse than the old alarm we must consider the number of incidences i.e. the number of people who pass the house each day and the percentage rate of burglars.

Imaging a scenario where the house is in a very busy but low crime area. Thus 1000 people pass the house each day but of these only 1% are burglars i.e. 10 of them. The old system would catch 95% of these burglars so 9 of them would have been caught but 1 may have managed to get away. The new system will catch 99.9% of them i.e. it will probably catch all 10. However the number of false alarms will also rise.

Of 990 innocent people passing the house the old alarm would have gone off 5 times (a false positive rate of 0.5%) but the new alarm will go off 30 times (a false positive rate of 3%).

The massive number of false alarms will not only waste time it will render the system so ineffective it would probably get switched off.

If you don't follow all of the maths in the example above don't worry about it. The lesson to be learnt from this is that if an experiment is conducted properly and the results are accurate it does not mean that a researcher's explanation of the results is a fair reflection of what those results show.

When evaluating research one of the steps involved is therefore to look at the results presented in the paper (either presented as numbers, presented as a graph or presented in a table format) and to consider is the researcher's discussion of those results is fair.

7.11 Unjustified Conclusions…

Finally if the research methodology is sound and the discussion of the results is fair it does not mean that the researcher conclusions are fully justified.

The limitations of the experiment could be overlooked, e.g. the small sample size or the specific nature of the organisation used in a case study, and valid conclusions could be overgeneralised making them no longer justified by the evidence.

7.12 An Example of a Researchers Conclusions

Activity 8

Consider the following scenario.

Action research is conducted to show if changing the sales approach by the sales staff in a car showroom will have a positive impact on sales. Staff are then trained to reduce sexist attitudes and the cost of this training is measured.

The results show that by reducing the sexist attitude of the sales staff they are much more effective when selling cars to woman and sales increase by 10%, and this despite the small cost of the training causes a significant increase in profit margins.

The researchers conclude that sexist attitudes in sales staff significantly impedes sales and improved staff training can have a significant impact on profit margins.

Evaluation of the research shows it was conducted meticulously and the results show what the researchers claim they show.

Only one question remains for you to consider now: are the conclusions fully justified given this evidence?

Feedback 8

At first glance the researcher's conclusions sound plausible however no consideration is given here to the nature of the organisation i.e. car sales. It is possible that in another business having sexist staff may have no effect on sales. Imagine staff working in a women's clothing boutique…would it matter if they were sexist against men when they are not trying to sell to men?

Whatever the research study the last step in evaluating the research is to evaluate the final conclusions to check that these are fully justified by the evidence and not overly generalised.

Researchers can be lured into making overly grandiose claims as this makes the research seem more impressive.

7.13 Accepting Conclusions as Valid

So before we accept conclusions we must critically evaluate the evidence…

Was the **method** used for the experiment scientifically sound? ✓ ✗

Were the **results** accurately and fairly reported? ✓ ✗

Were the **conclusions** fully justified by the evidence? ✓ ✗

If the answer to all of these is **yes** then we accept the conclusions are valid.

7.14 Learning More about Critical Evaluation

Activity 9

Bad science kills!

If you want to gain a deeper understanding of bad science which will help you when critical evaluating research, then read 'Bad Science' by Ben Goldacre, Harper Perennial Publishers.

This book is a short, cheap and humorous book and I highly recommend this to you as a source of further reading.

Feedback 9

There is no feedback for this activity.

7.15 One Additional Thought…

The tobacco industry, the petrochemical industry, the pharmaceutical industry and the alternative medicine industry are all big businesses. Annually these businesses combined are worth billions or trillions globally, and they all have powerful lobby groups.

Sadly good science has been deliberately undermined by big business for financial gain.

Activity 10

If you want to know more about how the tobacco industry and big business have tried to undermine science you can read the following two sources:-

Lopipero P.A. and Bero L.A., (2006), **'Tobacco interests or the public interest: 20 years of industry strategies to undermine airline smoking restrictions'**, Journal of Tobacco Control , Aug 2006; 15(4): 323–332.

Available from…
http://tobaccocontrol.bmj.com/content/15/4/323.full.pdf+html

You can also read:-

Oreskes, N. and Conway E.M.M, (2011), **'Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming'**, Bloomsbury Press.

Available from…

http://hope.econ.duke.edu/sites/default/files/Merchants%20of%20Doubt%20(2)%20OCR%20tiny.pdf

Feedback 10

By critically evaluating research and verifying well justified conclusions we can help combat those who try to undermine good science.

7.16 Summary

In this chapter we have seen that science is essential but that an element of scepticism is needed.

We have discussed the potential for flawed conclusions to be made in research (accidentally or deliberately) and thus we need to evaluate:-

- the methodology
- the reporting of results and
- the claims or conclusions reached.

We have looked at numerous ways research methodology can be flawed including:-

- Confounding Variables
- Complexities with Comparative Studies
- Badly Randomised Groups
- The Order Effect
- The Placebo Effect
- Correlation/Causal Confusion
- Surrogate Outcomes:
- Data Not Cleaned
- Poor Data Collection
- Biased Data (Accidental)
- Biased Data (Deliberate)

And we have seen that big businesses can gain from deliberately undermining good science.

By evaluating research you can:-

- Point out flawed research and thus potentially save lives,
- Suggest new avenues for research by suggesting ways valid methods and ideas can be combined and thus you can make a contribution to science,
- Give positive affirmation to properly conducted research and thus encourage others to apply the research findings where appropriate.

Ultimately the purpose of this chapter is to help you gain the skills to accept or reject the claims others make by looking at the evidence and applying sound scientific reasoning to determine if those claims are valid.

These skills are useful not just when evaluating research but also when making important life decisions.

8 Plagiarism, Citations and References

Introduction

In the previous chapters we tried to develop an understanding of research and develop practical skills that will help you to write a research paper:-

- Firstly to understand that writing a paper requires you to evaluate research, compare theories and to present your own conclusions.
- We looked at a breadth of research being done, across numerous subjects, to help you develop ideas for your paper.
- We looked at how to find a cohesive set of research papers so you will be able to find the papers you need.
- We looked at actual research papers to develop your understanding of the contents.
- We tried to develop an understanding of research methods, experimental design and bad science so you will have the skills to evaluate the methods, the discussion of results and the claims researchers make.

From now onwards the focus of this book will move away from understanding research and will instead focus much more on the act of writing your research paper.

As the topic of plagiarism is essential we will look at this first.

Objectives

By the end of this chapter you will understand:-

- How applying citations and references properly is essential to ensure you are not accused of plagiarism
- How to cite your sources,
- How to write a references list,
- The difference between the British and Harvard systems,
- And how the issue of plagiarism has an impact on the contents of a survey paper.

This chapter consists of 7 sections:-

1) What is Plagiarism?
2) Citations and References
3) The British or Harvard System
4) The Reference List
5) The Impact of this on the Body of Your Research Paper
6) The Difference between a Reference List and a Bibliography
7) Summary

8.1 What is Plagiarism?

Plagiarism is theft!

- Theft of words,
- theft of diagrams or
- theft of ideas.

At University it is a serious academic offense but it is simple to avoid.

Research builds upon the work of previous researchers so you will need to refer to their work. This is perfectly acceptable if you follow some simple rules:-

- If you use any words that are not your own these words must be inside quotation marks " " and a citation must be put next to the quote to identify the source.
- If you use a diagram that is not your own again the source must be cited.
- If you take a specific idea that is not your idea but was summarised in your own words again the source must be cited. Remember plagiarism is also the theft of ideas.

8.2 Citations and References

At the end of any document, including a research paper, there should be a reference list. This is a list of all the sources cited.

There should be a 1-1 relationship between the citations and the references i.e. if a source is cited it should be on the reference list and every item on the references list should be cited.

8.3 The British or Harvard System

There are two commonly used ways of citing sources they are called the British or Harvard methods.

The British method uses numbers…[1], [2], [3] for the citations and the reference list is therefore numbered accordingly. Thus the citation [3] points to the third item on the reference list which will of course also be numbered [3].

One advantage of this method is that it doesn't take much space to cite numerous sources and if research papers are very constrained in length this is a big advantage. Using the British method is therefore required by some conferences or journals.

One disadvantage of this method is that if you add or delete a citation all of your other citations must be renumbered and the numbers of the associated references must also be changed. This is a task that must be done carefully else a citation that should point to the third reference may incorrectly point to the fourth. It's easy to make this mistake when using the British system and hard to spot and correct any errors.

By comparison the Harvard method uses an author's name and the year of the publication as the citation, e.g. (Smith, Alison, 2010). When using the Harvard method the reference list is not numbered but is put in alphabetical order…this makes it easy the find the details of the paper published by Alison Smith. Though for this to work the formatting of the names in the reference list must be the same as in the citation so if the citation is 'Smith, A.' then the reference list should also be 'Smith, A.' and not 'Alison Smith'.

One advantage of the Harvard method is that it becomes easy to add or delete citations and as the name is in the citation and the reference list it is easy to spot and fix any errors.

One disadvantage of the Harvard method is that citations are longer particularly if the paper has more than one author. To keep Harvard citations from becoming excessively long when citing a source published by numerous authors only the first 2 or 3 names are given. The citation indicates the others by using 'et. al.' which translates to 'and the others'.

Thus '(Smith, A., Jones, B. et. al., 2015)' indicates a source published in 2015 written by 3 or more authors the first two of whom are called Smith and Jones.

You should not use 'et. al.' in a reference list but provide the names of all authors.

Activity 1

There is one very small complication with the Harvard method of citing sources…If the name of the author is part of the sentence then when citing a source the brackets, ( ), only go around the year.

Given this look at the following citation and correct it.

(Smith Alison, 2010) undertook research into….'

Feedback 1

In the example above the sentence does not start with 'undertook research into'. This makes no sense. The name is part of the sentence so the citation should be as follows…

Smith Alison (2010) undertook research into….'

Sometimes the choice of using the British or Harvard method is left up to the author however if a paper is accepted for publication extremely precise formatting instruction are usually provided by the publisher and the author is expected to follow these. These can include specific formatting instructions for the citations and references.

8.4 The Reference List

A reference list provides all of the important details regarding the sources cited in the body of your paper.

Activity 2

Assume you have been given a bill to pay.

Look at the following details and decide which details are important and which are unimportant:-

- The bill arrived by post (as opposed to email).
- You must pay £100.
- The bill is to be paid your landlord for rent due.
- The bill must be paid within 1 week.

Feedback 2

It is irrelevant how the bill arrived. Whether by post or by email the bill must still be paid.

The other details are all important as you need to know who to pay, how much you must pay and when it must be paid by.

Just as it was not important how the bill arrived so it is not important how you obtained a research paper. What is important is what are the details of the research paper and where was it published.

References that refer to research papers should therefore provide the following details:-

- The names of all of the authors,
- The year the paper was published,
- The title of the research paper (usually in quotes),
- The title of the journal or conference where the paper was published (usually in italics),
- The volume and page numbers i.e. exactly where in the publication is this specific paper.

Some people add additional details to a reference list but these are not required and can distract the reader from the important information.

For example some people provide the web address where the paper can be found as this makes it easy to obtain the paper. However in a badly formatted reference list this can make a reference to a good quality research paper appear to be a reference to a low quality web source. Web addresses are therefore not required and can be a hindrance.

Activity 3

Look at the reference list below, written in the Harvard format, and identify 5 errors:-

Scheme, E 2011, Electromyogram pattern recognition for control of powered upper-limb, Journal of Rehabilitation Research & Development, Vol. 48, pages 643–660.

Khokhar, Z, Menon, C, et. al., 2010, Surface EMG pattern recognition for real-time control of a wrist exoskeleton, BioMedical Engineering Online 2010, pages 1–17.

Young, A.J, Smith, LH, Rouse, EJ, Hargrove, L.J., A new hierarchical approach for simultaneous control of multi-joint powered prostheses, The Fourth IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics, Roma, Italy. June 24–27.

Feedback 3

The errors are as follows:-

- The references are not in alphabetical order so if the reference list is a long list it will be hard to find the details of the paper by one particular person.
- Title of paper is not in quotes and the title of the journal is not in italics making it hard to spot where one title finishes and the other starts.
- 'et. al.' is used in the second reference so one or more of the authors of this work are not being given the proper credit.
- The year is missing from the third reference so it will be very difficult to track down the source of this paper.
- Page numbers missing from the last reference making it hard to find just the relevant pages in the journal.

A corrected reference list is provided below:-

Khokhar, Z, Menon, C & Xiao Z G, 2010, 'Surface EMG pattern recognition for real-time control of a wrist exoskeleton', *BioMedical Engineering Online 2010*, pages 1–17.

Scheme, E 2011, 'Electromyogram pattern recognition for control of powered upper-limb', *Journal of Rehabilitation Research & Development*, Vol. 48, pages 643–660.

Young, A. J, Smith, L H, Rouse, E J, Hargrove, L.J., 2012, 'A new hierarchical approach for simultaneous control of multi-joint powered prostheses', *The Fourth IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics*, Roma, Italy. June 24–27, pages 514–520.

Note in the reference list above web addresses, where the paper can be downloaded from, have not been provided and the title of the journal or conference is clearly highlighted in italics. This makes it easy for the reader to see that good quality research sources have been used.

In the example above we have seen how to reference research papers. Other rules exist for referencing other type of published materials e.g. newspapers, web materials, audio materials etc.

These are less likely to be useful when writing a research paper and are not covered here but are covered in the following book:-

Cite Them Right: The Essential Referencing Guide (Palgrave Study Skills) by Richard Pears and Graham Shields, 2013.

8.5 The Impact of this on the Body of Your Research Paper.

Regarding citations and references there are two important considerations when writing the body of your research paper:-

- All sources must be properly acknowledged.
- It must be clear which parts of the paper represent your analysis and which parts are your summary of research done by others.

Activity 4

Look at the following 4 paragraphs, taken from a survey paper provided in section 1.1 of appendix 1, and identify which paragraphs describe research done by someone else and which paragraph present this authors evaluation of the research described:-

"Anastasia, et. al (2012) proposed a technique of achieving a robust image steganography using a high payload method and edge detection, where hybrid edge detector is derived by unifying the fuzzy edge detector and the sobel and the Laplacian filters for simplicity, this method does not compute the real edges in an image but distinguishes between the sharp and smooth areas of the image so as to hide more secret data bits into the edge pixels. In this method, as well as the secret message, two property files which contain information regarding extraction of the secret message are also encrypted using 3-DES with the secret key provided by the user during the embedding process.

The experiments carried out to test this algorithm used the same images used by Chen et. al (2010) for their image steganography scheme, this is used in order to enable seamless comparison of both techniques, although they used colored images while Chen et. al (2012) used grayscale images. Factors used for comparing the two schemes included the hiding capacity in bits divided by three, the peak signal to noise ratio (PSNR) is also measured, a higher value of PSNR is considered better. Figure 1 below shows the result of comparing this method and that of Chen et. al(2010).

Lena	Chen et al. method	Our method					
		Laplacian OR fuzzy edges			Sobel OR fuzzy edges		
		RNG with step 1|2,3	RNG with step 1,2	NO RNG used	RNG with step 1,2,3	RNG with step 1,2	NO RNG used
Capacity	10,662 (bits) 0.65 (bpp)	15,295 (bits) 0.93 (bpp)	20,596 (bits) 1.26 (bpp)	30,987 (bits) 1.89 (bpp)	15,213 (bits) 0.93 (bpp)	20,490 (bits) 1.25 (bpp)	30,811 (bits) 1.88 (bpp)
PSNR	47.1	46.88	46.88	45.12	45.91	46.88	44.45

Figure 1. Comparison of test result from the proposed method by Anastasia et., al (2012) and the method proposed by Chen et., al. (2010).

Based on the results presented above, Anastasia, et. al. (2012) claimed that there method which uses a hybrid edge detector together with the sobel and laplatian filters to enable embedding additional secret messages in the edge pixels outperforms the hybrid edge detection method proposed by Chen et. al. (2010).

The result of evaluating this method showed that colored variants of the image set used by Chen et al (2010) were used in the experiment, these image set are used in many other image steganography experiments, making it a good choice. The experiment is repeatable due to the fact that it is the most widely used for testing image steganography. The use of colored variants of the images in the experiment with the new method might not give an accurate representation of the performance when compared to the method of Chen et. al., (2010) which uses grayscale variant of the same images, the use of encryption as part of the algorithm may also cause potential issues with performance and may cause significant change in the size of the stego image as compared to the original cover image, testing the new algorithm with only one other method might also not give an accurate measure of its potential performance as compared to other current algorithms in the market and those proposed in current research papers."

Feedback 4

You cannot present your analysis without first giving the reader appropriate information on the work you are analysing. Thus the first three paragraphs above describe research done by Anastasia, et. al. (2012). These paragraphs describe the aims of the research and some details of experiments. The results of the experiments were also presented, in figure 1. Finally the third paragraph describes the claims made by the researchers.

So these three paragraphs are all descriptions. None of this is quoted. To save space it is all summarised in the author's words, and the sources are cited. Lots of details are missing but full details of the source research paper are provided in the reference list so if the reader wants more details of the work done by Anastasia, et. al (2012) they can find the original paper.

The fourth paragraph above is different. This is not the work of Anastasia, et. al. (2012) but this is the analysis done by Muhammad Hussaini, the author of this survey paper. In this final paragraph the author provides their evaluation of the way the experiments were performed and they then present their own conclusions based on this analysis.

Apart from citing all sources properly it should be clear which parts of your paper describe and summarise the work of other researchers and which parts present your analysis and your conclusions.

One easy way to make your analysis stand out a little is to put this in a separate paragraph.

As a survey paper evaluates the work of many research papers the descriptive parts will be very short and lack lots of important details but this is OK as these details should be in the source papers.

It should still be clear which parts are summaries of the work done by others and these parts will have lots of citations.

8.6 The Difference between a Reference List and a Bibliography

In books you may find a bibliography. A bibliography is not a reference list and should not be confused with a reference list.

A reference list is a list of sources cited.

A bibliography is a list of sources used but not cited.

If you take a specific idea from a researcher then you must cite the source and provided details of the source in the reference list. For example Anastasia, et. al. (2012) claim that their method outperforms an alternative method proposed by another researcher. This is a specific claim made by a specific source and the source should be acknowledged.

A bibliography is used where you may have taken a general idea but do not want to give credit to a specific person for that idea. For example imagine that when writing an essay you read a book that explains why the weather is difficult to predict. You could have found the same information from numerous other books and therefore do not want to credit the author of the book with this general information. In this case you would describe the general idea in your own words. You would also list the book in a bibliography but you would not cite the source in the body of your essay.

A bibliography is therefore a list of sources where you have obtained useful general information which you summarise in your own words but where the information is so general you do not want to credit that information to a specific author.

A bibliography is a way to acknowledge the source of your information without giving them the credit for information that could equally have come from other sources.

Of course if the author of this book then gives you specific ideas on how to improve weather predictions systems then the author should be given credit for these specific ideas and thus if this information is summarised in your essay the source should be cited and the book listed in the reference list.

If you do quote words, take a diagram, or take specific information you must cite the source and put the details in a reference list.

Bibliographies are commonly used when writing essays but should be avoided when writing a research paper as when writing a research paper you will be evaluating specific research.

Bibliographies and reference lists are not the same and should not be confused.

8.7 Summary

In this chapter we have discussed…

- How using citations and references properly is important to ensure you are not accused of plagiarism.
- How you must cite the source if a) you use any words that are not your own, and these words must be inside quotation marks b) if you use a diagram that is not your own and c) if you use a specific idea that is not your own even if this is summarised in your own words.
- How there should be a 1-1 correlation between the citations and the references
- The differences between the British and Harvard referencing methods.
- We have seen how the reference list must show all importation information and should be in alphabetical order if using the Harvard system.
- We saw how the body of your research paper should be structured clearly to distinguish between places where you describe the work done by others and places where you present your own analysis.
- And finally we looked at the difference between a bibliography and a reference list.

9 Practising Academic Writing

Introduction

In the previous chapter we have looked at the standards expected in academic writing and in particular looked at how sources should be cited and how a reference list should be presented.

We will now focus on the skills required to write the content of your paper in particular we will consider how to present well-reasoned objective arguments as opposed to presenting subjective personal opinions or beliefs.

Objectives

By the end of this chapter you will have had the chance to practise your writing skills and in particular:-

- practise writing a critical evaluation,
- practise writing a comparative analysis
- and practise considering how theory can be applied.

This chapter consists of 6 sections:-

1) Moving from Opinion to Reasoned Argument
2) Presenting Relevant Conclusions
3) Considering Critical Evaluation
4) Practising Comparative Analysis
5) Practising Application of the Theory
6) Summary

9.1 Moving from Opinion to Reasoned Argument

You may well have been told that in academic writing you should not present your personal opinions and should avoid using the word 'I'. At the same time you may have been told that you are expected to present your conclusions.

If you are to present your conclusions is it not therefore reasonable to write 'I believe…', 'I think…' Or 'In my opinion…'?

The instructions you may have been given could seem contradictory and confusing.

Here we will look at how you can avoid personal opinion and avoid using phrases such as 'I believe' and yet still present your conclusions.

Activity 1
Think about a gadget, hobby, sport or holiday destination you really like and write one or two sentences to express your feelings.

Feedback 1
A valid answers for this could have been…'I like the Harry Potter films' or 'In my opinion the Harry Potter films are great.'
Whatever the subject you may have written something that uses phrases to express your feelings…'I like…', 'In my opinion…' Or 'I feel' are all valid phrases here.

Telling a friend what film, hobby or sport you like could persuade them to see this for themselves especially if they know their tastes are similar to yours…on the other hand if their tastes are very different it could dissuade them. Either way it is unlikely that telling a stranger what you like would persuade them at all.

It is far better to remove personal statements such as 'I like…' or 'In my opinion…' and instead present a reasoned argument (see example below):

> The Harry Potter films present a story about the struggle to be honourable and brave in the face of fear, a plot that appeals to both adults and children. The world portrayed in these films is imaginative and rich in detail (e.g. ghosts that interact and have social lives etc.) and this is well demonstrated by the special effects. These are therefore very good films.

Activity 2

Rewrite the statement you made above by removing the personal element, i.e. remove any use of the word 'I', or 'in my opinion' and instead present an objective and dispassionate reason why the 'thing' is good. Try to write this is such a way that the conclusion you have reached does not depend on personal opinion or taste.

Ask a friend to review your statement and confirm that this does not present a personal subjective opinion.

Feedback 2

Your friend will hopefully be able to give you feedback on this.

9.2 Presenting Relevant Conclusions

So far the conclusion you have reached is just that 'something is good' but this should now be based on sound reasoned argument.

Having presented a reasoned argument and removed personal opinion you are far more likely to persuade someone to our point of view but we could make much better use of this argument by using it to make specific recommendations or reach specific conclusions. The more specific and relevant we can make our conclusions the more useful and impressive they are likely to be.

Activity 3

Reread the statement below:-

The Harry Potter films present a story about the struggle to be honourable and brave in the face of fear, a plot that appeals to both adults and children. The world portrayed in these films is imaginative and rich in detail (e.g. ghosts that interact and have social lives etc.) and this is well demonstrated by the special effects.

Now consider the following conclusions that could be reached about the Harry Potter films:

a. These films are therefore films most people would enjoy.
b. These films are therefore films many people would enjoy and are recommended to people who have not yet seen them.
c. These films are therefore good family entertainment and are recommended to parents with children, unless the people concerned particularly dislike films about fantasy or magic.

Look at each of these conclusions and decide which of them you find most persuasive.

If you are working with a friend ask them to complete the same exercise and compare your answers.

Feedback 3

The first thing to note about these conclusions is that they do not stand alone. Without justification these conclusions lack any merit. The conclusions follow on from the reasoned argument presented earlier and must be completely justified by the arguments made.

Regarding the first conclusion, 'These films are therefore films **most** people would enjoy'. You may have struggled with the word 'most'. 'Most' means more than half and there is no justification presented here to show that more than half of the population would enjoy these films.

You may have therefore felt the second conclusion had a better justification as this only concluded that 'many' people would enjoy them though the recommendation here is very wide ranging i.e. they are recommended to everyone 'who has not yet seen them'. That is a lot of people!

In the third conclusion the recommendation is significantly more limited. The films are only recommended to parents with children…and not even all of those. This is not to say others would not enjoy the films it's just that they are being specifically recommended for this particular audience.

There are two specific lesson here:-

1) The conclusions must be justified by the arguments made.
2) Wide ranging conclusions, while they may have a wider potential impact, are more difficult to justify and can be less persuasive.

Activity 4

Rewrite and extend the reasoned argument you wrote earlier about a hobby gadget, sport etc by adding a conclusion that is as specific and as persuasive as possible yet still applies to a number of people.

Ask a friend to read this and give you feedback on:

1. The conclusion, is it clear, specific, unambiguous and does it apply to many people?
2. Is your conclusion persuasive and fully justified by the reasoning presented above?

Feedback 4

Hopefully a friend will be able to give you feedback on your reasoned argument and conclusion.

From this you should see that presenting good reasoned argument can justify conclusions and conclusions that are specific and well justified can be useful and persuasive. They should certainly not be based on a personal point of view and therefore there is no need to use phrases such as 'I believe' 'I feel' or 'I think'.

While you presumably believe your conclusions are valid they should be justified by evidence and well-reasoned argument. It is irrelevant that you believe them and using a phrase such as 'I believe' detracts from the objective reasoned argument you should present.

If you want to emphasise that these are your conclusions a better phrase would be 'I therefore conclude that…' But still the use of the word 'I' can be avoided here.

One alternative phrase that avoids the use of the word 'I' is 'The conclusion is therefore reached that…'.

From the writing it can be made clear that this is the author's conclusion i.e. you can make it clear that these are your conclusions but conclusions you have reached based on well reasoned argument.

The purpose of writing a research paper is to present your analysis and meaningful conclusions. It is these conclusion that make your paper worth reading. An important part of this is to ensure that these conclusions are based on sound reasoned argument and not personal opinion or bias. Hence we have considered how to move away from personal opinion to present reasoned argument and how to present meaningful conclusions.

When writing a survey paper your analysis will come from three aspects:-

- Critical evaluating individual research papers,
- Comparing the methods or theories proposed by different researchers
- And considering the application of these theories in real world situations

We will practice two of these aspects of writing shortly.

9.3 Considering Critical Evaluation

Critically evaluating research is the hardest and most substantial of these tasks. It requires an understanding of research theory and requires an evaluation of the experimental methods, the discussion of results and ultimately an evaluation of the claims researchers make.

As this is such a significant topic chapter 7 was devoted to this and these skills were practised in sections 7.6–7.12 but you can continue to practise these by writing some evaluative text.

Activity 5

If you want to practise your critical evaluation skills further you can either:-

1. download a research paper and evaluate the methods, discussion of results and researchers claims,
2. or you can practice your critical evaluation skills on a real life situation. For example consider a policy that is being proposed by a politician or consider an expensive product e.g. a luxury car being sold. Consider the evidence presented by the politician or salesperson, is the evidence sound? Does the politician or salesperson present a fair analysis of this? and are their conclusions sound?

Write a paragraph or two to describe the evidence and the claims made (in doing this avoid any analysis or judgement by yourself – just stick to a factual description).

Then write one paragraph where you present your evaluation of the evidence and the claims made and finish this paragraph with your conclusion i.e. do you conclude that the claims made are valid or false?

Feedback 5

Ask a friend to read your description and answer the following questions.

a. is your description clear and factual?
b. have you presented clear arguments with your conclusion at the end? Note your conclusion should always come after the analysis. Putting the conclusion first with the reasons following implies bias.
c. are your arguments based on an objective analysis or personal opinion – or are they somewhere in between?
d. have you managed to avoid using personal terms such as 'I think' 'I believe' or 'in my opinion'.

9.4 Practising Comparative Analysis

A comparison can also lead to specific conclusions. Thus as well as reaching conclusions by evaluating a piece of research we can reach meaningful conclusions by comparing different theories, methods and ideas proposed by different researchers.

Activity 6

Read the comparison below and then answer the questions that follow:-

1. Identify one similarity between the items being compared
2. Identify one difference
3. Identify the conclusions and ask a) is this justified by the comparison b) is this conclusion very general or is the conclusion more specific i.e. is there a clear and specific message here that could have an impact in a specific situation?
4. Given the conclusion go back and look at the comparison. Are any parts of this comparison not relevant to the conclusion? If so could this comparison be shortened by removing some of the detail?

The Harry Potter films are much more recent than Alfred Hitchcock's film 'Rear Window', which was released in 1954, and there are many clear differences including the genre, fantasy or thriller, the intended age of audience and the use of, or lack of, special effects. Yet there are also clear similarities: both include ordinary characters, e.g. children or a person with a broken leg, that the audience can empathise with. Both plots also move forward at a reasonable speed and both include moments of real tension e.g. moments when the lives of main characters are at risk. Therefore when writing new films, irrespective of the genre, authors are encouraged to focus on developing characters the audience can relate to and developing plot lines that have moments of significant tension.

Feedback 6

1. This comparison highlights clear similarities:- characters the audience can empathise with, moments of tension, reasonably paced plots.
2. This comparison also highlights clear differences:- the genre, age of the film and use of special effects.

3a. Very importantly the conclusions are directly related to and justified by the comparison presented earlier.

3b. The conclusion is also reasonably specific. It is specific to a group of people i.e. budding film authors and the recommendations made are also quite specific i.e. irrespective of genre create characters the audience can relate to and developing plot lines with tension.

4. The description and comparison of these films is already quite short but could be shorter still. In the comparison above there are parts that are not directly used in this conclusion i.e. the age of the films, use of special effects and speed of plots. Thus we could have made this comparison a little shorter by removing some of this detail yet still provided all of the required information needed to justify the conclusion.

Similarly we could have made our comparison longer and more detailed by comparing the number of actors in the films, the age of actors, language used in scripts or any other aspects of the films but we need to ask if this extra detail is relevant.

Comparing the age of actors etc is not relevant to the conclusion and therefore this should not have been added to the comparison.

Comparing script devices etc could however have been very relevant. This would have taken our analysis to a much deeper level and possibly have allowed us to make specific recommendations on how to create moments of tension. This would have therefore added real value to the conclusions.

A comparative analysis can lead to meaningful and useful conclusions but the conclusions must be justified by the comparison.

By comparing the methods, ideas and new theories proposed by researchers you can reach specific conclusions and this is one way your survey paper can make a valuable contribution to science.

The deeper the comparison and the more insightful our conclusions are the more value we add.

When comparing new methods proposed by researchers you can consider:-

- which method will work best?
- would combining the different methods give us a method that is potentially better than either method in isolation?
- if two methods should be combined how would this work?
- will the methods, together or on their own, solve the problem or do parts of the problem remain to be solved?

When writing a survey paper we are often constrained in word length and so should keep our descriptions as short as possible yet the more detailed our analysis is the more valuable our conclusions can be.

One way of resolving this conflict is to:-

- Write the comparison, ignoring word length, and make this as detailed and meaningful as possible.
- Then draw your conclusions making these as specific and useful as possible.
- Think carefully and check the conclusions are fully justified by the comparison
- and finally revise the comparison and descriptive parts to make these as short as possible by removing any unnecessary detail.

Activity 7

Think about the gadget or hobby or whatever else you wrote about earlier and write a short comparison between this and a different gadget or hobby.

From your comparison try to reach conclusions backed up by the comparison you made and write these down as well.

Show this to a friend and ask them to give you feedback on the following:

1. Is the conclusion you present reasonable given the comparison?
2. Is there any irrelevant detail in the comparison that could be removed?

Feedback 7

Hopefully a friend will be able to give you feedback on your comparison and conclusion.

9.5 Practising Application of the Theory

After comparing research theories another way of reaching useful conclusions is to consider the application of the theory to real world scenarios. By doing this you will also be able to make specific conclusions about how the theories may, or may not, help and who should, or should not, apply these theories.

Activity 8

Consider two cars both costing exactly the same:-

Car A is a small two seat sports car, with leather seats, fast acceleration, the ability to park in small spaces but has poor fuel consumption and virtually no luggage space.

Car B is a largish 7 seat car with a large luggage compartment. It is slower to accelerate but especially on motorways is fairly fuel efficient.

Imaging you were a car salesperson and answer the questions below…

1. What sort of customers would you recommend Car A for?
2. What sort of customers would you recommend Car B for?
3. Are there some customers for which neither car A or B is appropriate and if so why?

Feedback 8

You may consider car A to be appropriate for a young single person, in a well-paid job, especially one working in a city as they may prefer a small car that is easy to park. They may also enjoy the status symbol of a sports car and if they have no family to transport only having two seats will not be a problem.

You may decide to recommend car B for families with a number of children especially those that use the car for holidays and therefore do a fair amount of motorway driving.

There are other customers for whom neither car is ideal e.g. customers who have only 1 or 2 children but who want a large car with a powerful engine that can safely tow a caravan or customers who want a small fuel efficient car for local about town driving.

By considering the use of these cars we can make specific recommendations. In doing so we are not saying that one car is better than the other just that each is useful in some circumstances but less useful in others.

Considering practical and specific situations will allow you to consider if and where it is best to apply new theories proposed by researchers.

A researcher may have developed a new method and shown through testing that this method works but that does not mean it will work well in all situations. By considering different situations and how the proposed new method works you can make specific recommendations, backed up by well-reasoned argument, about when others should apply the new method or when it should be avoided.

By considering the application of new research theories to situations the original researchers may not have considered you can reach useful conclusions and make a contribution to knowledge.

9.6 Summary

In this chapter we have practised the academic writing skills that are important when writing a research paper. There are many good books on this subject that you can read if you wish to take this subject further.

In particular you should now see that:-

- Presenting your opinions is much weaker than presenting reasoned argument and when presenting reasoned argument you should write this to avoid personal statements e.g. I believe…, I feel…, I think… In my opinion…
- Reaching specific conclusions is worthwhile and these can be persuasive but these must be backed up by well-reasoned argument.
- Reasoned argument and useful conclusions can come from evaluating research i.e. to determine which researchers conclusions are valid and which are not.
- We can also reach useful conclusions by comparing different research theories or proposed methods i.e. to determine which methods or theories are best, or to determine if there are benefits from integrating these (but if so how is this to be done).
- And we can reach useful conclusions by considering the application of theories and methods to real life scenarios and thus we can make recommendations regarding the application of these new theories or methods.

When presenting good written work it is not enough to summarise what you have read. You must also present your analysis and your reasoned argument. This is the value you add by analysing your subject matter.

It is by presenting your reasoned analysis and your well-argued and justified conclusions that makes the effort in reading your work worthwhile.

10 Drafting a Research Paper

Introduction

You should by now have the skills needed to find a cohesive set of good quality research papers and the skills needed to understand the research methods used by the researchers.

You should have a good understanding of research theory and have practised applying your knowledge to the act of critical evaluation.

In the previous chapter you practised the skills needed to write about research and present a reasoned analysis covering three different aspects that will allow you to present valuable reasoned conclusions:-

- By critically evaluating individual research papers,
- By comparing the methods or theories proposed by different researchers
- And by considering the application of these theories in real world situations.

We will now focus on a process you could follow to help you write your own research paper.

Later chapters of this book as will focus on the skills needed to write specific sections of a research paper e.g. the introduction, the body and the abstract. This chapter will focus on the overall process.

Objectives

By the end of this chapter you will understand the process drafting and refining a research paper. You will see how you can make a real start by focusing on the first easy steps and how you can tackle the harder parts one section at a time. You will also understand how a critical friend can help you.

This chapter consists of 17 sections:-

1) A Path Through the Forest
2) Drafting, Drafting, Drafting
3) A Day Starts by Getting out of Bed
4) Define General Structure and Headings
5) Write a Rough Introduction in Note Form
6) Add One Descriptive Section (i.e. summarise one research paper)
7) Add the Other Descriptive Sections
8) Evolve and Refine the Structure of Your Paper
9) Draft the Evaluation Sections

10) Drafting the Comparative Analysis and the Application of the Theory
11) Draft the Conclusions
12) Drafting the Abstract
13) Refine, Refine, Refine
14) Feedback from a Critical Friend
15) Your Own Brain Can Trick You
16) Check Formatting, Citations and References
17) Summary

10.1 A Path Through the Forest

You may have walked on paths through a forest.

You may have also noticed in places where there is no proper path but where a well worn track has been made by previous walkers.

If a route taken by a few walkers is poor then other walkers will find a different route and the plants damaged by the first walkers will re-grow and the route they took will disappear.

If on the other hand the first walkers find a good route through the forest other walkers will follow the same route and over time the track taken will become well worn and clearly evident to other walkers.

Thus well worn tracks are evidence that many walkers have used that route and these are often good ways of getting through a forest.

Path makers don't usually create paths just because they think a path in a particular place would be useful. Instead they look for well worn tracks and turn these into proper paths.

Thus good paths evolve over time.

The story you tell when writing your research paper is the path you create through the forest. The research papers you have found are the trees. The path is the coherent story you tell that flows and makes sense of the research.

Activity 1

Imagine if you received a visitor from abroad, someone who knows nothing about your nearest large city. Now imagine they want to visit this city alone for a day.

Consider two completely different stories you can tell them about this city if a) they want to go shopping or b) they want to visit the main tourist highlights.

1. What would you tell them about first?
2. What would be the main things you want to tell them about if a) they are going shopping b) they want to visit the main highlights?
3. What would you tell them about in the end?
4. What would you not tell them about?

Feedback 1

If I was to introduce someone to London I would start by explaining how to get into the city, the structure of the city centre and how to get around the city.

If my visitor wanted to go shopping I would tell them about Oxford street, Bond street and Mayfair where they would find the most impressive shops. I would also tell them about Covent Garden where they can find imaginative arts and crafts and about Notting Hill where they would find interesting markets.

If my visitor wanted to visit tourist attractions I would tell them how to get to Buckingham Palace and the Tower of London. I would tell them where the big museums and art galleries are and where to get a cruise on the Thames.

I would finish by making sure my visitor knew how to get home safely.

There is so much that I wouldn't say either because it isn't relevant or just because I wouldn't want to overload my visitor with too much information. Whole districts in London would not get mentioned. Neither would I mention about the night life nor would I overload them with information about less important attractions or shopping areas.

Whatever story you tell is up to you to decide. It is up to you to decide a) how your story starts, b) what are the main points you want to get across (and in what order) and c) how you want your story to end.

10.2 Drafting, Drafting, Drafting

Whatever story you decide to tell it must flow well and be easy to follow. To achieve this, like a good path, the story must evolve over time.

Just as there are many paths through a forest, each with its own start and end point, so there are many stories you can tell using a set of research papers.

It often does not matter where your introduction starts, nor will you have a specific set of conclusions to reach. The story you tell is for you to create.

What does matter is your story must make sense. Like the path the starting point must be clear, the flow must make sense and each step of the journey must be logical. To do this your path, your story, must evolve over time.

No matter how careful you are and how detailed your plans are you cannot write a good paper by starting at the beginning and working through each section in fine detail until you get to the end.

Your paper must iterate through a process of continual improvement. In other words it requires initial plans, very rough drafts, more drafts and refined drafts. In the early stages the structure may change radically. In the final stages each step of the story you tell must be fine-tuned.

The story is yours to tell and while is requires multiple drafts it is reasonable to have a general idea where you want to start and where you generally want to end up.

By iterating and revising your paper you can make sure the flow of your paper makes sense and each step of your reasoned argument is logical.

10.3 A Day Starts by Getting out of Bed

You may have heard the phrase 'A journey starts with a single step' similarly a day starts just by getting out of bed…. Let's explore that process a little.

Activity 2

Consider the following options and choose which you feel best describes your approach to life.

When you get out of bed do you:-

1. live from one moment to the next without making any plans at all?
2. briefly plan the main things you need to do that day, revise these plans if required as the day progresses, and leave the more detailed planning for each major event until that event becomes confirmed?
3. plan the day in great detail from beginning to end before you start doing anything?

Feedback 2

If you don't plan the day at all you are unlikely to achieve much on the other hand if you plan each step in fine detail before you do anything at all you run the risk of a) never getting started and b) wasting effort planning events in detail that will never happen.

Option 2 is perhaps the most sensible approach to life.

Planning your writing requires a similar approach to planning your life.

There is a risk that you will see the task of writing a research paper as a **huge and daunting task,** one so scary that you will never start.

Rather than focussing on the mountain that needs to be climbed instead take the first few steps.

Take the first few steps, then the next few steps and soon you will have made a real start.

So don't plan your paper in endless detail. Instead:-

1) make initial plans…they will change anyway.
2) then start filling in little bits of your paper…i.e. take the first few steps
3) fill in a few more bits and see your paper start to take shape.
4) look at your planned structure and, like a path, let it change and evolve as it needs to
5) Continually draft and refine your paper as is goes.

Don't delay – take those first few steps today!

By focusing on the next small step you start to make real progress and the whole task becomes less daunting.

Don't start on the difficult bits. Don't even think about the difficult bits. Take each task one step a time and the whole thing becomes manageable.

You can break the task of writing your survey paper into the following steps:-

- Define the general structure i.e. the headings for each section of your paper
- Write a rough introduction in note form
- Add descriptive sections (i.e. describe the research)
- Draft evaluation sections
- Draft a comparative analysis
- Draft your conclusions

10.4 Define General Structure and Headings

Start by giving your paper some structure. Looking at the title of your paper and the research papers you are using as your sources try to decide what the major sub topics are and which papers fit into each sub topic.

Don't discard papers that are a little off topic – we will learn how to deal with those later.

Once you have identified the major sub topics decide what order you want to tackle these in your paper. Then create headings for each of the sections of your paper.

After your paper has covered these topics in isolation you may want to a) compare the theories, b) consider application of the theory to different real world situations and c) and present your final conclusions. These sections of your paper will also require suitable headings.

Thus your survey paper may start with a structure similar to the following:-

- Introduction
- Research topic A
- Research topic B
- Research topic C
- Comparing theories A-C
- Considering application of the theories
- Conclusions

Obviously the heading should be specific to your specific paper and the structure can and should change as you refine your ideas.

10.5 Write a Rough Introduction in Note Form

The parts of your paper where you present your evaluation and reasoned argument are the hardest parts to write. They require real thought and this is where you will make a real contribution to knowledge but for now you can ignore these parts and focus on the simple parts.

So take the first real step and write an introduction in note form…don't worry about making this a perfect well written introduction as it will surely need to change and evolve.

For now just make notes and keep this brief. Remember you are not writing an introductory essay but you are writing about advanced research. You are writing to professionals so explaining basic terms and concepts is not appropriate.

So in brief note form:-

- What is the problem your paper is trying to address?
- What are researchers trying to solve?
- What are the major topic your paper will consider?

Activity 3

If you have found and read your research papers and if you have a rough idea of the structure of a paper you want to write then you can write your introduction now in rough draft form.

Feedback 3

There is no feedback for this activity but if you manage to do this then ***Well done!*** – ***you have made a real start.***

Don't worry if your rough notes look rough. Making a start is important and no matter how good your first draft is it will still need revising and changing.

10.6 Add One Descriptive Section (i.e. summarise one research paper)

Still avoiding any complex parts of your paper you can start the body of your paper by summarising the research described in **one** of the papers you have read i.e. write a few short paragraphs to:-

- Describe the problem the researchers are trying to solve
- Describe their methods
- Describe their experiments and results and
- Describe their conclusions.

This summery should be all descriptive and should not be hard to write.

Ensure you cite your source in your summary and add the details of the paper to your reference list.

Add your summary to the correct section the body of your paper.

10.7 Add the Other Descriptive Sections

You can continue to build up the body of your paper by repeating the step above and summarising each research paper adding its summary to the relevant section of your paper.

By the time you have finished this some sections of your paper should then contain the descriptions of several research papers. Other sections, e.g. the comparative analysis and your conclusions will still be blank.

You can leave a few blank lines after each section that describes research as this will be where you will add your evaluation.

10.8 Evolve and Refine the Structure of Your Paper

As your paper takes shape consider the flow of the topics and the section headings.

- Do your section headings reflect the papers/topics covered in each section?
- Are you tackling the sections in the right order?
- Do small sections need merging?
- Do large sections/topics need segmenting into several sub sections?

Let your paper structure evolve as you refine your ideas and go back and refine your introduction accordingly.

10.9 Draft the Evaluation Sections

After drafting the introduction and the descriptive parts of your paper you are now in a position to start adding your analysis.

Remembering by evaluating the methods, discussion of results and conclusions you can reach your own conclusions about the validity of the researcher's conclusions.

So evaluate one of the research projects, write up your evaluation and add this to your paper immediately after your summary/description of this research.

You can take one research summary at a time, evaluate this, add your evaluation to your research paper and repeat this process until you have evaluated all of the research projects you have described.

10.10 Drafting the Comparative Analysis and the Application of the Theory

After evaluating the research you should now be able to compare the different theories and consider the application of the research to real world scenarios and add these sections to your paper.

10.11 Draft the Conclusions

You should now be able to summarise all of your analysis and conclusions and draft your overall conclusions.

10.12 Drafting the Abstract

As your paper now looks like a complete draft you should now be able to draft an abstract summarising the work your paper.

10.13 Refine, Refine, Refine

As this stage you should have a rough draft of your complete paper but it will still need to be refined, refined and refined.

- Consider the overall structure and flow:- does this need revision?
- Consider each section of research evaluation:- does your analysis stand up to scrutiny? Will a sceptical reader accept your conclusions as sound? And is your evaluation based on sound scientific arguments?
- Can your descriptive parts be refined now you know what your evaluation says?
- Refine your comparative analysis: – is your reasoning detailed and do your arguments make sense?
- Refine your consideration of the application of theory:- again do your arguments stand up to scrutiny?
- Refine your overall conclusions to ensure they are fully justified by your earlier reasoned argument and ask yourself has your analysis lead to useful specific and well reasoned conclusions i.e. has your reasoned analysis made a real contribution.

10.14 Feedback from a Critical Friend

It is at this point your draft paper should be looking quite good and this is where a critical friend can help you.

You want to find out how good your paper is so test the null hypothesis…i.e. ask a friend to consider where the weakest parts of your paper are.

- Where is the flow of ideas poor?
- Where are the headings unclear or vague?
- Where is the description poor?
- Where are the weakest points of your evaluation and reasoned argument?

Getting a friend to give you feedback on the problems can be very helpful in making your paper better.

10.15 Your Own Brain Can Trick You

Activity 4

Your mind is powerful and can make sense of garbage!

To prove this try to read the message below:-

> I cdnoult blveiee taht i cluod aulacity uesdnatnrd waht i was rdgnieg. The phaonmneal pweor of the hmuan mnid, aoccdrnig to rsceearch at Cmabrigde Uinervisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoatnt tihng is taht the frist and lsat ltteer be in the rghit pclae.
>
> The reset can be a taotl mses and you can sitll raed it wouthit a porbelm. tihs is bcuseae the huamn mnid deos not raed ervey lterter by istelf, but the wrod as a wlohe. Amzanig eh? And I awlyas tohghut slpeling was imporantt…! And for thsoe of you wtih mroe tmie tahn ohrets, you wlli ntocie taht not olny are msot of the wrosd a mses but smoe of tehm are cpmlpoetley msiseplt awslel…!

Feedback 4

Some people can make sense of this but don't worry if you can't. Not everyone can and you will probably struggle if English is not your first language.

A translation of this message is as follows:-

"I couldn't believe that I could actually understand what I was reading. The phenominal power of the human mind, according to research at Cambridge University, it doesn't matter what order the letters in a word are, the only important thing is that the first and last letter be in the right place.

The rest can be a total mess and you can still read it without a problem. This is because the human mind does not read every letter by itself, but the word as a whole. Amazing, eh? And I always thought spelling was important! And for those of you with more time on your hands than others, you will notice that not only are most of the words a mess but some of them are completely misspelt as well!"

Some people can read this text and this shows how powerful the mind is.

When you read your brain is not trying to read every word and every letter. Instead your brain is trying to make sense of the sentence.

This causes a problem when you are trying to fix grammatical and logical errors in your written work.

When you re-read something you have written your brain actively tries to ignore the errors to extract the meaning and thus the text will make sense to you. You 'see' what you expect to see – you don't see the text exactly as it is written i.e. you won't see the errors unless you can force your brain to slowly check each small part of the sentence.

Your own brain can trick you into believing your written work is error free.

One way to make it easier to spot errors is to review a printout of your work.

A printout of your work makes it look sufficiently different and it becomes easier for your brain to spot the errors.

Re-reading it when you are less familiar with it also makes it easier to spot errors.

Thus before you submit any written work always check it, one final time, by looking at a printout – preferably several days after having written the text.

10.16 Check Formatting, Citations and References

Finally check the formatting, citations and references all satisfy any given instructions.

Papers which are to be published must match the formatting striations carefully. This takes time, care and attention to detail.

If you are working to a deadline you must allow sufficient time for the final edit.

10.17 Summary

In this chapter we have discussed how:-

- You should not be daunted by the whole task of writing a research paper but should instead take one step at a time.
- You should focus on the first simple steps and start writing quickly.
- You can't plan each section in detail before you start instead your paper must evolve as you refine your ideas.

- As your paper evolves so the structure, headings and introduction will change.
- Getting feedback from a critical friend is essential.
- Checking a final version on paper and allowing time for the final edit is also important.

If you have been doing all of the exercises in this book you may already have the structure of your first draft planned and a draft of your introduction written…If so well done!

The following chapters of this book will focus on how to write each section of your paper in more detail:-

- The introduction
- The body of your paper
- The conclusions
- The abstract

11 Writing an Introduction

Introduction

In the previous chapter we looked at the process of writing a research paper.

In this chapter we will focus on writing the introduction. Writing a good introduction to a research paper is not the same as writing a good introduction to an essay.

Objectives

By the end of this chapter you will have been able to consider what makes a good introduction and test your understanding of this.

This chapter consists of 4 sections:-

1) An Introduction as a Funnel
2) Using Those Less Relevant Papers
3) Considering Two Introductions
4) Summary

11.1 An Introduction as a Funnel

In chapter 3 we considered how to find a cohesive set of research papers and how to choose a title for your research paper. We saw that the title needs to reflect the purpose of the paper, which is to present your analysis and evaluation of current research, and importantly the title should be focused and reflect the narrow subject matter.

In looking at this we considered one good example of a title that reflects both the purpose and the focus:- 'A Critical Evaluation of Current Neural Network Theory for Number Plate Recognition Systems'.

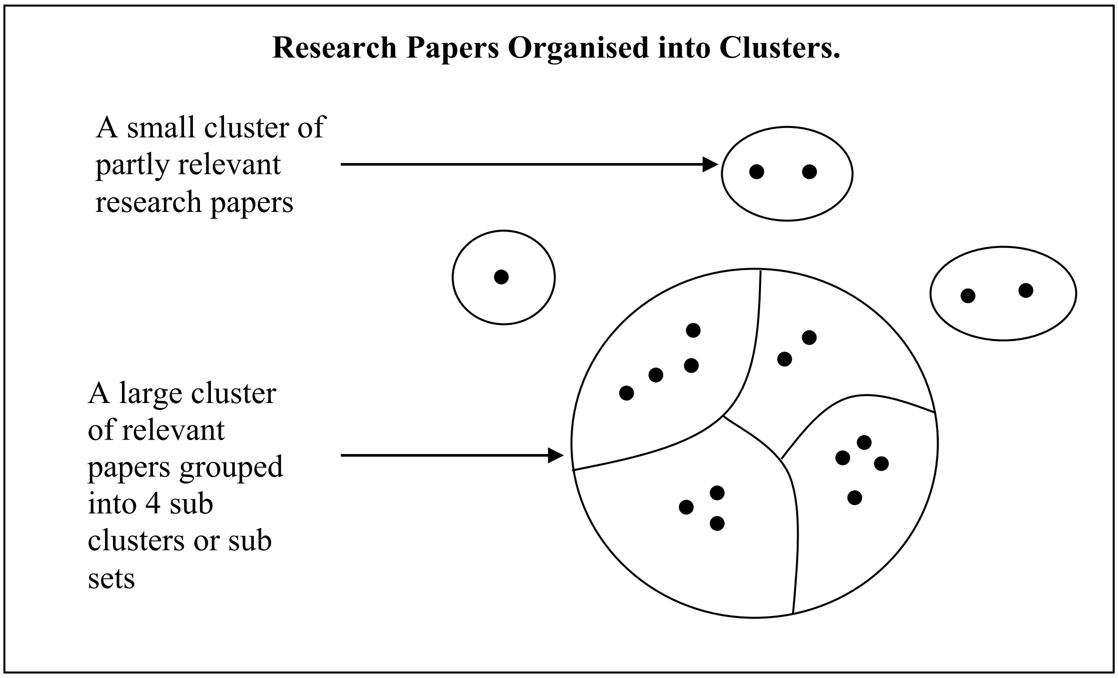
So the title of your research paper should already be focused and clearly it should reflect the subject matter of your paper.

However while the title should reflect the subject matter covered in the paper it may not perfectly reflect the focus of the body of the paper.

Consider the set of research papers you are working from. These will not be all of the possible research paper you could have used. Clearly you will have rejected papers that are not relevant to your title but there will be other relevant papers that you simply didn't find or didn't have time to read. Therefore you will be working on a subset of the possible papers.

There may also have come across some papers that don't seem quite as relevant as others.

Consider the cluster diagram below:-



This diagram shows a large set of relevant research papers that have been organised into 4 smaller clusters i.e. 4 sub sets. The large set represents the most relevant papers found which a researcher has chosen to base their paper on. The diagram also suggests that the paper will have 4 subsections and indicates the number of papers that will be discussed and evaluated in each of these subsections.

The diagram also indicates some less relevant research papers. These are not research papers that have been rejected as being irrelevant. Instead these are papers that are generally relevant i.e. they fit within the topic however they are papers that the researcher has chosen not to focus on.

There could be many reasons why you would choose not to use some papers that are still relevant given your paper title…perhaps because they are a little old and discuss a now discredited theory or perhaps you could only find one paper on that particular sub topic or perhaps you just want to focus on a different area.

For whatever reason you may have rejected some papers that are relevant but are not quite on the area you wish to focus your discussion on.

We will see how we can use these less relevant papers shortly.

For now we will just note that the papers you wish to focus on are a subset of papers that you could have used.

Given this your research paper title may not perfectly capture the focus of the body of your paper. This is perfectly OK and it does not mean your title needs to be changed.

You do not need to define a title that is so precise it includes only those papers you wish to discuss and excludes all of the others.

Instead however you should recognise the existence of the other papers, i.e. the related research that is being done within the overall area, but focus the readers mind on the particular area you wish to concentrate on.

Thus your introduction needs to act like a funnel.

Research Paper Heading

Main Body

The introduction should focus the reader on a very narrow topic – probably narrower than that defined by the heading alone.

What is the problem?

What research is being done to solve that problem?

What is the focus of this specific paper?

11.2 Using Those Less Relevant Papers

In chapter 4 we discussed the aim of research being to add a piece of knowledge to the existing body of human knowledge and by analogy we are trying add a brick to a wall of knowledge.

Your research paper is trying to add one brick to the wall. This does not just sit on top of other bricks – it has bricks at either side and this needs to be reflected in your introduction.

Your introduction should explain the aim of your paper to your readers and thus it needs to explain the purpose of your paper, i.e. the brick you are trying to place. It should also explain where in the wall this brick goes i.e. where it fits related research.

Thus you should not just bin the less relevant papers you have found. Instead you should, in your introduction, briefly explain the research that is related to your paper.

By mentioning the related research you show where in the wall of knowledge you are trying to add your brick. This shows a wider understanding on your part and helps to improve your paper by allowing the reader to see where your research fits into the existing body of knowledge.

Your discussion of related research should be very brief. You should not describe the research nor do you need to make any effort to evaluate the related research. Your purpose is only to show to the reader that related research is being done and to briefly explain how this relates to your work.

While you are only mentioning the related research in passing, i.e. very briefly, you must still cite the sources and add the details of these papers to your reference list.

11.3 Considering Two Introductions

We have discussed how your introduction should explain the purpose of your research paper and focus the readers mind on the specific topics you are discussing and evaluating. In doing this your introduction should also mention research that is related to yours.

Activity 1

Rather than getting you to practise and develop your skills by asking you to write an introduction you can test your understanding by evaluating two previously written introductions.

Read the 'Introduction 1' below and answer the following questions:-

1. Was this introduction written with other researchers in mind?
2. Is it short and nicely focussed on the subject or is it too long or too wide?
3. Does this introduction explain a problem and introduce the reader to research?
4. Does this introduction focus the reader on the purpose of this specific paper?
5. In short, is this a good or bad introduction for a research paper?

Introduction 1) Research into Current Internet Security Methods

The internet has become an essential part of life. People use it not just to get current news but to interact socially through websites such as 'Facebook' and to manage their financial affairs with online shopping and online banking etc. People also now use online health tracking applications that monitor health activity, location and time etc.

However as our reliance on this technology increases so does our exposure to online threats.

Furthermore recent trends involve ever increasing use of cloud storage, where 'data is maintained, managed and backed up remotely and made available to users over a network (typically the Internet)' (www.whatis.com), means that more of our personal data is not stored at a secure local physical location and our risks are even greater.

Recent evidence has shown security breaches and hundreds of millions of records stolen in the US (www.bloomberg.com/graphics/2014-data-breaches).

Security protection is therefore critical to prevent hackers from gaining and abusing confidential information.

The following are all steps users can take to protect themselves:-

- *Use anti-virus software*
- *Install firewalls*
- *Avoid pirated software*
- *Using strong passwords*
- *Beware of internet phishing*
- *Ensure data is transmitted in an encrypted format.*

This paper will explore each of these and aims to make specific recommendations for users wishing to stay safe online.

Feedback 1

This introduction may be a good introduction for an essay but it is a very poor introduction for a researcher paper and there are several clear reasons why this is the case.

1. Was this introduction written with other researchers in mind?

   Firstly this introduction starts by explaining our ever increasing reliance on the internet – and of course we all know this. It also inappropriately defines terminology i.e. 'cloud storage'. Not everyone will know what cloud storage is and in an essay defining terms like this is fine. However computer professionals doing research to develop advanced internet security methods don't need basic terminology to be defined. Thus this introduction is more appropriate for novices not researchers.

2. Is it short and nicely focussed on the subject or is it too long or too wide?

   As an introduction this is nice and short however while this is all under one subject of internet security this is broken down into 6 very different subjects…and each one of these can again be broken down into smaller subjects. Thus while this may be a good introduction for an essay, for a research paper this is far too wide a topic.

3. Does this introduction explain a problem and introduce the reader to research?

   The introduction does explain the problem and cites a web site as evidence – citing a web site for this sort of evidence is fine – however while this then introduces the reader to the sub topics it does not introduce the reader to research being done. Nowhere does it mention researchers who are trying to push forward the boundaries of knowledge and nowhere does it cite research papers.

4. Does this introduction focus the reader on the purpose of this specific paper?

   The introduction does explain the purpose of this paper but again there is a problem here. The aim is to make recommendations for the public. This is not an appropriate aim for a research paper. A research paper should aim to evaluate current research evidence and reach conclusions by comparing and considering the application of advanced theories. Recommendations could come from this but these are likely to be very specific and aimed at other professionals and researchers. They are not likely to be general recommendations that anyone would understand.

5. In short, is this a good or bad introduction for a research paper?

   This is not a good introduction for a research paper though it may well be fine for an essay.

Activity 2

Now consider 'Introduction 2' below and answer the same questions:-

1. Was this introduction written with other researchers in mind?
2. Is it short and nicely focussed on the subject or is it too long or too wide?
3. Does this introduction explain a problem and introduce the reader to research?
4. Does this introduction focus the reader on the purpose of this specific paper?
5. In short, is this a good or bad introduction for a research paper?

Introduction 2) Current EMG Pattern Recognition Research Aimed At Improving Upper Limb Prosthesis Control

The application of electromyogram (EMG) pattern recognition in the control of upper limb prosthesis has been a popular topic of research over the last five years. However, it is not clinically used due to its limited dexterity (Scheme, 2011) and EMG recordings can become unreliable over time (Zhang et. al. 2013) making the limbs not suitable for everyday situations. Hargrove, L.J. et. al. (2013) conducted research into increasing the number of EMG channels to improve the accuracy of the pattern recognition system without needing more electrodes. Amsuss et. al. (2014), Scheme (2011) and Zhang et. al. (2013) provide research into making prosthesis more clinically viable and allowing the user more intuitive control.

EMG pattern recognition could offer the user more control of the prosthesis, including allowing them to gain more movement and control of the force they put into their movements, as it will learn how the EMG changes depending on the user's intent (Khokhar, Z et. al. 2010).

This research paper will focus on studies that have been carried out on using EMG pattern recognition to improve upper limb prosthetics. The paper will discuss different classification strategies, results of the research and critically evaluate the strength of the outcome. Conclusions will be made throughout the paper regarding how each method will affect the prosthesis and then finally summarized at the end. The primary object of these papers was improving the dexterity of upper limb prosthesis. This paper uses the research of those that focused on improving the pattern recognition and artificial intelligence by looking at the classification errors and processing time.

Feedback 2

1. Was this introduction written with other researchers in mind?

   From the title and the terminology used in the opening paragraph it is clear that this introduction was aimed at people who already had a significant level of knowledge in the subject. Many people would struggle to understand this but this is an indication that this is aimed at researchers and interested professionals. It is not an indication of bad writing.

2. Is it short and nicely focussed on the subject or is it too long or too wide?

   It is very short and has a very clear focus.

3. Does this introduction explain a problem and introduce the reader to research?

   Within the space of two sentences the problem is explained and research papers are cited as evidence. Before the end of the first paragraph 4 research projects are explained, 3 in just one sentence, with sources correctly cited. There is no description or evaluation here…this is just a mention of related research in passing.

   If any description or evaluation of the research was conducted this would be done in the body of the paper not the introduction.

4. Does this introduction focus the reader on the purpose of this specific paper?

   The purpose of this paper is explained, i.e. to evaluate 'how each method will affect the prosthesis' and while is not explicitly stated it is reasonable to presume that this research paper will reach new and specific conclusions or make specific recommendations that will prove informative either for other researchers wanting to improve the methods further or for those involved in manufacturing or fitting a prosthesis. In other words it is expected that his research paper, by its evaluation of the methods, will make its own contribution to the development of prosthetics.

5. In short, is this a good or bad introduction for a research paper?

   In short this is an excellent introduction.

Activity 3

The second introduction above was taken from one of the three research papers in appendix 1.

Take a look at the other two introductions as see if you think these are appropriate for a research paper.

Feedback 3

While these introductions are all written to make then as easy to read as possible they are all short, focussed and presume the reader will have a certain level of knowledge.

They all introduce the reader to research being done in a specific area, citing research papers, and they all explain the purpose of this specific paper.

They all imply that the analysis presented makes a contribution to our knowledge of the subject.

These are all good introductions.

11.4 Summary

In this chapter we have seen that writing an introduction to a research paper is not the same as writing an introduction to an essay.

We have also seen that a well written introduction should:-

- Be short and focussed and written for professionals and researchers.
- Act like a funnel and focus the reader on a very narrow topic – probably narrower than that defined by the heading alone.
- Highlight a problem caused by the limitations of human knowledge, citing evidence where possible, and introduce the reader to research being done to overcome that problem.
- Explain the aims of this specific paper highlighting the work that will be done in this paper. This highlights the analysis and evaluation to be done i.e. it explains how this paper hopes to make a positive contribution to knowledge in that subject.

12 Writing the Body of a Paper and the Conclusions

Introduction

In the previous chapter we considered how to write a good introduction to a research paper. This chapter will focus on how to write the body of the paper and the conclusions.

To write a good research paper requires the ability to:-

- find relevant research papers,
- critically evaluate research,
- perform a comparative analysis and
- consider the application of the theory.

These skills were all practised in chapters 3, 7 and 9 with associated theory and understanding being developed in chapters 1 to 6.

To write a good research paper also requires an understanding of plagiarism and the application of proper citations and referencing methods as practised in chapter 8.

Chapters 9 and 10 allowed you to practise your academic writing skills and consider the process of drafting your research paper.

In this chapter we will assume you have an understanding of all of this material and we will only consider how this material comes together to form the body of a research paper.

In other words this chapter will just consider the look and feel of the final product and thus this chapter will be quite short and simple…you have really done all of the hard work in the proceeding chapters.

Objectives

By the end of this chapter you will have considered each section of a research a paper focusing on the analysis that could be presented in that section and you will have considered ways to test the quality of a research paper you may write.

This chapter consists of 7 sections:-

1) Considering the Structure of Your Paper
2) Considering Your Evaluation Sections
3) Considering Where You Compare the Theories
4) Considering the Application of the Theory
5) Considering the Conclusions
6) Testing the Quality of Your Paper
7) Summary

12.1 Considering the Structure of Your Paper

In chapter 10 we saw how a research paper must go through a series of drafts so it can evolve into a well structured document where each step of the reasoning process is clear and well reasoned.

Activity 1

Presented below are the headings from three research papers. These headings describe the structure of these research papers.

Consider these headings for each of the 3 papers and answer the questions below:-

1. Are the headings clear, well worded and specific to the paper?
2. Do the structures of the papers flow in a logical manner?
3. Is it clear from the headings that the papers do more than just summarise the information in the source research papers?
4. Do the research papers end with a 'Conclusion'?
5. Are the references a numbered section?
6. Are there any differences in the way the papers are structured?

Paper 1) An Evaluation of Information Hiding Techniques Using Image Steganography

1. *Introduction*
2. *Evaluation of Current Steganography techniques*
3. *Comparison of current Steganography techniques*
4. *Conclusions*

References

Paper 2) Current EMG Pattern Recognition Research Aimed At Improving Upper Limb Prosthesis Control

1. *Introduction*
2. *Background*
3. *Linear Discriminant Analysis*
4. *Simultaneous Parallel Approach*
5. *Conditional Parallel Approach*
6. *Comparison of Pattern Recognition Techniques*
7. *Conclusions*

References

Paper 3) Positive and Negative: Effects Video Game Use Can Have on Personality Development

1. *Introduction*
2. *Aspects of Personality Development*
   2.1 Cognitive Effects
   2.2 Social Aspects
   2.3 Emotional Aspects
   2.4 Educational Aspects
3. *Discussion & Comparisons*
4. *Conclusions*

References

Feedback 1

All of these three research papers are presented in full in appendix 1. These are all good examples of the application of the theory taught in this book.

1. Are the headings clear, well worded and specific to the paper?

   All of the headings are clear but some of the headings are very general and could apply to any research paper. e.g. 'Introduction'. There is no reason why the first heading needs to be just 'Introduction' but neither is this a problem.

   If all of the headings were the same this would be a problem. Imagine a paper with the following headings:-

   Introduction
   Research theory
   Evaluation of theory,
   Comparison of methods,
   Conclusions

   These headings would be problematic as they give the reader no clue as to the content or subject matter covered in this specific paper.

   The headings presented in the examples do give a clear indication of the detail of the content covered in the specific paper, e.g. 'Evaluation of Current Steganography techniques', 'Linear Discriminant Analysis', 'Emotional Aspects'.

2. Do the structures of the papers flow in a logical manner?

   Yes

3. Is it clear from the headings that the papers do more than just summarise the information in the source research papers?

   Some of the headings specifically highlight the work done in this specific paper…e.g. 'Evaluation of…', 'Comparison of…'

   Other headings don't do this and just highlight the subject covered e.g. 'Simultaneous Parallel Approach', 'Aspects of Personality Development'.

   Either way it is important that each section of the paper does more than just summarise the material read. Each section should present the authors reasoned argument.

4. Do the research papers end with a 'Conclusion'?

   The papers don't end with a 'Conclusion' section – they end with 'Conclusion**s**'

   This small difference, **'s',** is important and we will discuss this later.

5. Are the references a numbered section?

   While it is critical to present a properly formatted list of references it is not part of the discussion or body of the paper. References are presented as a list at the end – hence this section is not numbered.

6. Are there any differences in the way the papers are structured?

   There are differences in the structures, most notably paper 3 has subsections and the others do not. It is up to the paper author to decide on an appropriate structure for their specific paper.

   In the examples above:- Paper 1 only uses a very few headings, Paper 2 presents a list of topics covered and Paper 3 presents a list of topics covered but organises these into sub sections.

   Larger documents, e.g. books, require sections, subsections and sub-subsections to provide an appropriate structure. Shorter research papers have less need of subsections, and rarely need to use sub-subsections at all, however should still use subsection where appropriate.

   As the 3rd paper considers 4 different aspects of personality development the author presented these as subsections.

   When using subsections a paper should first introduce the section before starting the subsections, as paper 3 does (see appendix 1).

2 Aspects of Personality Development
The following research will be split up into four different sections which will…

However you structure your paper its flow, like a path over a stream, must make sense to the reader.

Your path must lead the reader from a clear explanation of the problems and issues, as presented in the introduction, to the proposed solutions, as presented in the conclusions.

12.2 Considering Your Evaluation Sections

In the body of your paper you should of course be describing and evaluating research.

In doing this you should avoid judgemental language

e.g. 'this research was flawed…'

and instead present a professional judgement leading to a reasoned conclusion.

e.g. 'The researchers claim…however the experiments fail to consider the possibility of… therefore additional testing is required before we can be sure of the validity of these claims.

or…

The researchers tested a wide range of users taken from a random sample and the results show sufficient evidence to justify the claims made.

Remember your purpose is not to criticise the researcher written English or the depth of their literature search but to determine if the researcher's conclusions are valid.

Activity 2

Consider the section of a research paper presented below and answer the following questions:-

1. Can you identify which paragraphs describe the research?
2. Looking at this can you identify a) the experimental work conducted b) the results and c) the original researcher conclusions?
3. Can you identify where the evaluation starts?
4. In the final paragraph has the author evaluated the researcher's conclusions or are they going further?

A section taken from 'An Evaluation of Information Hiding Techniques Using Image Steganography' by Muhammad Hussaini

The experiment carried out by Ghebleh and Kanso (2013) was performed in order to gauge the performance of the proposed image steganography algorithm on the basis of its security, imperceptibility and feasibility. Randomization of the position of the stego-image which carried a secret message of size 2bpp and was embedded in the cover image ensured that a visual inspection of both the stego and cover image does not unveil the difference between the images. The histogram of both the cover and stego image was calculated, as well as the difference which shows that there is no significant difference between the two images as shown in figure 2 below.

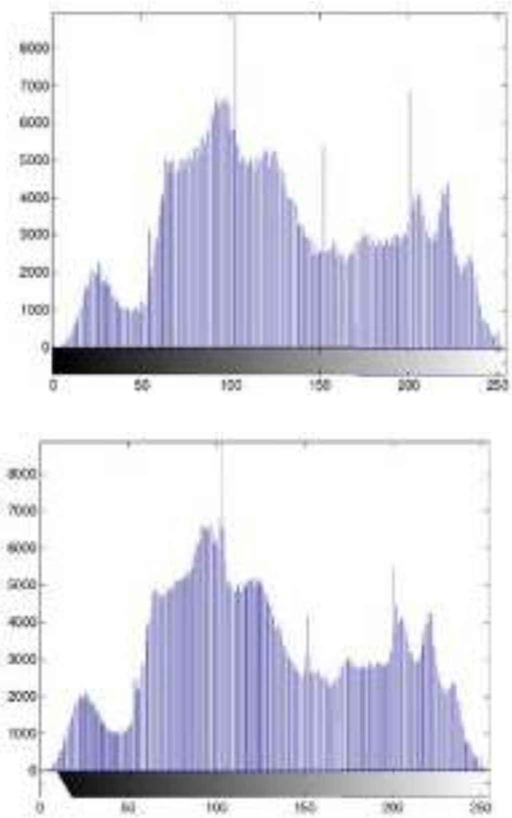


Figure 2. Cover media Image Histogram (Top), Stego Image Histogram (Bottom) (Ghebleh and Kanso, 2013).

The experiments they carried out measured the image histogram, the similarity measures were also calculated and presented based on existing units of similarity measure – the mean square error (MSE), peak signal to noise ratio (PSNR), and the structural similarity index (SSIM). The results of the experiment was also compared with three (3) current transform domain based image steganography schemes by (Raja et. al. 2008), (Souvik and Gautam, 2012) and (Gandharba and Saroj, 2012), this were chosen due to the fact that they all used colored images for their experiments, this enabled direct comparison of these schemes with the proposed scheme. The comparison table is shown in figure 3 below.

Cover	Message		Proposed	Raja et., al	Souvik	Gandharba
Saturn (512 × 512)	Parrot (384 Kb)	PSNR:	52.298	45.03	-	-
		SSIM:	0.9982			
Lena (512 × 512)	Random (38 Kb)	PSNR:	61.128	-	14.917	-
		SSIM:	0.9988	-	0.9834	-
Lena (512 × 512)	Random (125 Kb)	PSNR:	56.135	-	29.339	-
		SSIM:	0.9997	-	0.9743	-
Lena (512 × 512)	Random (116 Kb)	PSNR:	56.453	-	-	49.67
		SSIM:	0.9997			

Ghebleh and Kanso (2013) concluded that their proposed algorithm is superior to the algorithms it was compared to, they also presented evidence that showed they achieved a good imperceptibility measure based on the two units of similarity measure, which are PSNR and SSIM index, as well as having a high secret key sensitivity.

The research carried out by Ghebleh and Kanso (2013) was rigorous due to the fact that there proposed method was tested against attack from different steganalysis methods which use LSB replacement, the methods include the Chi-Squared Test (Westfeld Andreas, 2000), Weighted-stego analysis (Fridrich and Goljan, 2004) and Sample Pair analysis (Dumitrescu et al, 2003).

Results have shown that the method is effective against these techniques of steganalysis, although more test will need to be carried out to ascertain its strength against other forms of attack such as statistical steganalysis which are also very popular. The choice of 3D Cat map is applauded due to its sensitivity to even small changes in secret key used. Although, the application of a transform domain technique and the randomness of the choice of bits where data is hidden proves effect, the transform domain is known to cause reduction in the quality of stego-image produced

Feedback 2

1. Can you identify which paragraphs describe the research?

   The first 3 paragraphs presents a detailed description of the research conducted by Ghebleh and Kanso (2013).

2. Looking at this can you identify a) the experimental work conducted b) the results and c) the original researcher conclusions?

   a. The first paragraph explains the reasons for the research and explains how the experimental work was conducted. This description continues into the second paragraph. Part of this comparison highlights how the methods used by this researcher compared with the methods proposed by other researchers…' (Westfeld Andreas, 2000)…(Fridrich and Goljan, 2004) and…(Dumitrescu et al, 2003)'.
   b. The actual results are presented in figures 2 and 3. Parts of the text explain these results without making any judgments e.g. '…which shows that there is no significant difference…'
   c. The researchers conclusions are presented in the third paragraph…'Ghebleh and Kanso (2013) concluded that their…'

   All of this is descriptive. None of this is this author's evaluation.

3. Can you identify where the evaluation starts?

   The evaluation starts in the 4th paragraph with 'The research carried out by Ghebleh and Kanso (2013) was rigorous due to the fact that…'.

   The author is concluding that the researcher's conclusions are valid though they don't use these exact words.

   This paragraph could have been rewritten so the arguments are presented first and the conclusion is presented at the end of the sentence. If you start a sentence by making a claim that research is not valid this could cause the reader to disagree with you before you have given them a chance to hear your reasons. It is therefore better to present your reasoning first.

4. In the final paragraph has the author evaluated the researcher's conclusions or are they going further?

   In the final paragraph the author is not evaluating the validity of the researcher's conclusions. Here they are considering how effective the technique is. This is really an element where they are considering not the validity of the theory but the application of the theory.

   Consideration of issues like this can allow the research to reach conclusions about who should apply the theory and when it should be applied…or indeed if it is worth applying this method or theory under any circumstances.

Activity 3

Consider the one short paragraph below and answer the following questions:-.

1. This is part of the evaluation of some research described earlier in the paper. Do you note anything different about this evaluation?
2. This paragraph includes a citation – Does this look like the authors arguments or does this look like they are just summarising an argument presented in the paper cited?

A section taken from 'Current EMG Pattern Recognition Research Aimed At Improving Upper Limb Prosthesis Control' by Molly Sturman

This study did not test online control; however, there have been many other studies, such as Hargrove, L.J. et. al. (2011), which gives evidence of a strong correlation between online controllability and classification accuracy.

Feedback 3

In this paragraph the author is commenting on one limitation of the research conducted but notes that this limitation is not important as other studies have shown this correlation.

When evaluating research it is perfectly valid to cite other research papers that show related results. These results may help to confirm or contradict this researchers findings.

Doing this shows that this author has an understanding of related research and can use evidence presented on other papers when presenting their reasoning however care must be taken when presenting arguments such as this. When citing other papers with related evidence it is important that you are still clearly presenting your reasoned argument not just summarising an argument presented elsewhere.

In this case this author makes good use of evidence presented on other papers as part of their evaluation of this research. This is therefore very good work.

A large part of the body of your research paper should be devoted to describing research:- the methods used, the experiments conducted, presenting the results and presenting the researchers conclusions. Keeping all of this as short as possible and making sure the sources are correctly cited.

A critical part of this is to present your evaluation of this work:-

- Were the methods/experiments conducted sound?
- Was the discussion of the results fair?
- Do the results and evidence justify the claims reached?

Use the evidence to drive your discussion forward presenting your own reasoned argument and repeat the above for all of the research you wish to evaluate.

12.3 Considering Where You Compare the Theories

There are no fixed rules on how you should structure your paper and it is possible to compare the research theories within the evaluation sections of your paper. However it can be worthwhile at times to devote a specific section of your paper to presenting your comparison of the theories as this work is different and the types of conclusion reached are also different.

Here we are not interested in what theories are proven we are interested in which will work best therefore at this point a description and evaluation of the way experiments were conducted is not relevant.

These sections should instead describe the theories, and by comparing these, reach conclusions by considering the similarities and the differences.

Activity 4
Consider the section below and identify where the author is reaching conclusions based on their comparison.

A section taken from 'Current EMG Pattern Recognition Research Aimed At Improving Upper Limb Prosthesis Control' by Molly Sturman

6. Comparison of Pattern Recognition Techniques

The research evaluated throughout this paper all had an aim to improve upper limb prosthesis using EMG pattern recognition. The methods all had advantages and limitations stated in their conclusions and results allowing comparisons to be made for a recommendation for the most appropriate method.

The conditional parallel approach had advantages of low classification errors, as the results by Young, A. et. al. (2013) show that they had lower errors in both discrete and combined movements. This is a significant advantage as low classification errors will provide fewer problems for the user.

LDA does also have a low classification error, shown both by Young, A. et. al. (2013) and Chu, J. et. al. (2007), although not as low as the conditional parallel approach. It does, however, have a very quick processing time which will provide a more intuitive prosthesis for the user. Research into methods extending from LDA and improving the real life application may make it a more suitable option, however.

The research by Wurth, S.M., Hargrove, L.J. (2013) showed that, whilst simultaneous pattern recognition had advantages of high completion percentage and lower overshoot percentage over sequential pattern recognition in combined motions, there was the disadvantage of it having a slower performance in the discrete motions, whilst being equally efficient otherwise. The simultaneous approach is inferior to the other methods analysed as it shows no significant or consistent advantages in improving upper limb prosthesis.

The results all show that all three methods analysed have limitations, such as real life application or online control, which require further study to allow fully intuitive results.

Feedback 4

The comparison started by highlighting all the researchers had the same aim.

It goes onto to note that one method will cause fewer problems for the user and explains why this is the case.

It also explains why one method is inferior to the others.

This author is therefore presenting their own conclusions based on their comparison of the methods proposed by the different researchers and the reasons for each of these conclusions is presented.

Just as this author has evaluated the work of other researchers so the reader of this paper can decide for themselves whether or not this author has presented sufficient argument to justify their conclusions.

It is worth highlighting the final paragraph. The final paragraph points out the limitations of the theories when applied to real life situations and suggests that further research is required. This again is another example where the author is considering how well the research theory will apply in a real world situation.

12.4 Considering the Application of the Theory

As well as evaluating the research and comparing research theories there is another way of reaching valid and useful conclusions. This is by considering how well the research theories will work in real world situations.

These could be general situations e.g. you could show that a theory will never work fully and more research is needed.

Alternatively situation could be very specific e.g. you could argue that certain theories will work well under very specific situations but not well in others.

The more detailed and more specific your analysis the more scope you have to reach impressive conclusions.

General statements, such as 'more research is needed', can easily be made and are not particularly impressive. This particular statement could be improved by identifying a specific area where further research is needed and by providing a good justification for this.

Of course if the original researchers highlight an issue requiring further research and you echo their statements then this is not a conclusion you have reached from your analysis.

You don't make a contribution to knowledge by summarising or repeating what you have read but you can make a contribution to knowledge by considering in detail how well theories proposed by other researchers will work in specific situations.

We have already seen examples where conclusions have been reached by considering how well the theories will apply in real world situations…*'Results have shown that the method is effective against…more tests will need to ascertain…the application of this theory proves effective but is known to…the results show that all three methods have limitations such as…'*

When planning the structure of your paper it is up to you to decide whether or not this part of your analysis should occupy a separate section of your paper or if this analysis should be contained within other sections.

Placing it in its own section can highlight this work and concentrate your mind to ensure this analysis is as detailed and impressive as possible.

12.5 Considering the Conclusions

Finally we need to consider the last section of your research paper.

Your paper starts with a single 'Introduction' not with 'Introductions' should it therefore end with a section called 'Conclusion' or 'Conclusions'?

Activity 5

If the last section of your paper is called '**Conclusion**' does this imply your paper has a single final section or does it imply you have only reached one conclusion?

If the last section of your paper is called '**Conclusions**' does this imply your paper has a several final sections or does it imply you have reached several conclusions?

Which of these titles emphasises your achievements?

Feedback 5

If the last section of your paper is called 'Conclusion' it implies that this is the conclusion of your paper…the end. It does not imply you have reached any useful conclusions.

Alternatively if the last section of your paper is called 'Conclusions' this cannot imply it is the ending as your paper cannot have multiple endings. The word **conclusions** implies you have reached multiple conclusions. This emphasises the results of the analysis you have done. In other words it emphasises your claims to have made a contribution to knowledge.

Ending your paper with a '**Conclusions**' section therefore emphasises your achievements.

Activity 6

Consider the following section taken from the conclusions of one of the research papers in appendix 1 and decide if the conclusions reached are fully justified by the text shown below.

If the answer to this question is 'no' then where would you expect the justification for these conclusions to be?

Finally answer the following question. Should all of the conclusions go in the 'Conclusions' section of your paper or should they go somewhere else?

A section taken from 'Positive and Negative: Effects Video Game Use Can Have on Personality Development' by Shaun Watson

4. Conclusions

…From our research we can conclude that playing violent video games consistently can result in a decrease in empathic concern and prosocial behavior although they allow an individual to vent their built up anger without consequence.

There are many aspects of the effects that video games can have on personality that we have not looked at in this research, we have only covered a very minute section of the potential research that could be conducted but the research covered is important as it exposes the fact that video games do have an effect on personality, positively and negatively.

Finally, we can see from this research that video game use can result in an increase in cognitive abilities, provide social interactions with others, provide emotional help and possibly an increase in academic performance which in turn could result in an adolescent becoming more motivated and intelligent and improve various life skills such as decision making and problem solving.

Feedback 6

The conclusions presented in this text are not justified here. The analysis and justification for each of these is presented in the body of the research paper.

Throughout the body of your research paper you should be presenting your reasoned analysis and the fully justified conclusions that come from this. This reasoned argument must be strong enough and sound enough to stand up to scrutiny by a sceptical reader.

This discussion will be detailed and interspersed with descriptions of research and theories.

Thus your conclusions should come throughout the body of your paper not just in the final section.

Your 'Conclusions' section allows you to summarise and bring together your individual conclusions and leave the reader with a clear impression of the results of all your analysis.

This is made simpler as the detail and the justification can be ignored here…if the reader wants to question the validity of your conclusions then they can read the body of your paper.

12.6 Testing the Quality of Your Paper

There are three ways to test the quality of your research paper:-

1. If someone reads your conclusions will it be clear to them that you are presenting conclusions you have reached…of course it should be…or are you just summarising what other researchers have said?
2. Secondly do your conclusions make a real contribution to knowledge? They don't need to be earth shattering unless you are claiming to be Einstein but you should be making clear and specific claims that others will find useful.
3. Finally by checking each part of your reasoned argument check that your conclusion are fully justified. Check that your arguments demonstrate sound scientific reasoning and that they would convince a sceptical reader.

12.7 Summary

In this chapter we have considered the structure of a research paper. We have considered how the discussion must flow like a path that is easy to follow.

We have considered the sections where you present your evaluation of the research and in doing so how you must describe research aims, experimental methods, results and the claims researcher make.

We have seen how our evaluation must consider each aspect of this i.e. were the methods sound, the discussion of the results fair and were the claims fully justified?

We have seen how we can cite evidence from other research papers to help us present our evaluation.

We have seen how a comparison of theories can lead to specific conclusions.

We have also seen how we can consider the application of theory applies and reach conclusions from this.

We have seen why our paper should end with 'Conclusions' not a conclusion.

Finally we have considered three tests we can apply to assess the quality of our research paper.

13 Writing an Abstract

Introduction

We have now considered how to write the introduction, body and conclusions to our research paper.

We will now focus on how to write a good abstract.

Objectives

By the end of this chapter you will have been able to evaluate good and bad abstracts and in doing so test your understanding of what makes a good abstract.

This chapter consists of 3 sections:-

1) An Abstract Is Not An Introduction
2) Good and Bad Abstracts
3) Summary

13.1 An Abstract Is Not An Introduction

An abstract is a summary of the entire research paper including the conclusions. For this reason the abstract should be written after the paper is finished.

From experience it seems that many students are aware of the difference between an abstract and an introduction and yet they often write poor abstracts.

There could be a simple reason why students write abstracts that read more like introductions…Research paper abstracts are put at the start of the paper. Thus they can be mistakenly treated as the first part of the paper to be read i.e. they can be treated as if they were the introduction.

This chapter aims to give you the skills to write a good abstract.

Activity 1

Consider the following summary of the book Harry Potter and the Philosopher's Stone.

This story is about a boy Harry Potter, who at the age of 11 finds out he is a wizard and that a scar on his forehead was caused by a dark wizard who killed his parents. Harry goes to a magical school called Hogwarts and makes good friends with two other children Ron and Hermione and together they have magical adventures with ghosts, centaurs, broomsticks and an invisibility cloak.

Now consider the following summarised version of chapter 1.

Chapter one describes an ordinary family, the Dursley's, who live in fear of some relatives called the Potter's. It describes strangely behaving owls, tabby cats and people wearing cloaks. It finally describes several very unusual people, one of whom is a giant that arrives on a flying motorbike. They put a baby called Harry on the steps of a house in Privet Drive and leave.

Now answer the questions below:-

1. If you were to read the book without reading the first of these summaries would the book still make sense?
2. If you read the first summary and then didn't read the book would the summary on its own make sense?
3. If you were to read the book starting at chapter 2, without first reading chapter 1, would the book make sense?
4. Which of these two summaries is an abstract?

Feedback 1

1. If you were to read the book without reading the first of these summaries would the book still make sense?

   The book would make perfect sense without this summary. While people often read a summary of a book is not necessary to do so. People can, if they want, jump straight in and start reading at chapter 1 and the book will make perfect sense.

2. If you read the first summary and then didn't read the book would the summary on its own make sense?

   A summary such as this is often found on a book cover and by summarising the entire book it acts like an advert that a person can choose to read or ignore. The summary makes sense on its own as it summarises the whole book. Notice while it summarises the whole book and provides some details '*and together they have magical adventures with ghosts, centaurs, broomsticks and an invisibility cloak'* it does not actually spoil the ending of the story by giving too much information away.

   A good summary contains enough detail and summarises the entire story without spoiling the ending.

3. If you were to read the book starting at chapter 2, without first reading chapter 1, would the book make sense?

   Chapter 1 is not a summary. It is part of the story. If you start reading the story at chapter 2 you will not initially understand what is going on when you read about Harry and the strained relationship he has with his aunt and uncle.

4. Which of these two summaries is an abstract?

   The first of these summaries is an abstract. It summarises the entire story and it is not part of the story. You can read the abstract and choose not to read the story. Alternatively you can read the story without reading the abstract.

   The abstract should be treated as an entirely separate document. A good abstract is a good summary that leaves the reader wanting to read the story.

   By contrast chapter 1 is part of the story. Reading chapter 1 on its own will leave you with unanswered questions… What happened next? Similarly the story will not fully make sense if you don't read chapter 1.

   The introduction is part of the story without which the story does not fully make sense. It is not a separate document.

A good abstract summarises an entire research paper and in doing so it needs to contain enough detail about the work done in that research paper. It must summarise the entire paper including the conclusions without spoiling the ending i.e. without giving the actual conclusions away. By summarising the entire paper a good abstract will act like an advert for the paper by making it clear that the paper makes a useful contribution to knowledge.

While an abstract is presented at the start of a research paper, before the introduction, it should be treated as an entirely separate document.

Activity 2

Consider the two sections presented below, taken from a research paper, and identify which is the abstract and which is the introduction.

Section 1 taken from 'An Evaluation of Information Hiding Techniques Using Image Steganography' by Muhammad Hussaini

Protecting the privacy of information for organizations, governments and individuals have become increasing challenging in recent times due to the increased use of computers and digital means of communication. Various methods of protecting information and privacy have been researched and developed,

…[*part deleted*]…

Raftari and Moghadam (2012) also claimed that by combining Integer Wavelet Transform and Discrete Cosine Transform which are both transform models, a more secure image steganography method was achieved based on results that showed good value of Peak signal to noise ratio (PSNR) in the secret image, an acceptable visual quality which leaves the secret data unnoticed, Mean structural similarity index measure (SSIM) and the Histogram error (HE).

The aim of this paper is to critically evaluate and analyze current research focused on developing more secure methods of image steganography, models and techniques used, conclusions and claims reached based on experiments carried out and their results.

Section 2 taken from 'An Evaluation of Information Hiding Techniques Using Image Steganography' by Muhammad Hussaini

Steganography has become the technique of choice for hiding secret messages in a cover media, presenting and transmitting it as a harmless piece of content, therefore making it hard to detect unlike encryption. This paper provides an adept evaluation of some of the prominent image steganography methods, showing their strengths, weaknesses and applicability, further conclusions were made regarding the effectiveness and otherwise of the techniques evaluated.

Feedback 2

The first of these is not an abstract – it is the introduction to a research paper. It starts by explain what the problem is about. It then describes related research and finally explains the aims of this paper (future tense as these aims have not yet been achieved).

The second of these is an abstract. To make it readable it does spend one sentence explaining what the problem is. It does not talk about related research but just summarises the work done in this paper (past tense) and says something about the conclusions.

The abstract tries to be specific and detailed enough so that a potential reader of the paper can see just what was done without giving the actual conclusions away.

13.2 Good and Bad Abstracts

A good abstract should therefore:-

- summarise the work done in the research paper it describes
- it should also present a summary of the conclusions in such a way that it makes the reader want to read the paper itself,
- while an abstract should be specific it should also be relatively short.

Activity 3

Read the following 7 abstracts, numbered 1–7. Note ways in which you think the abstracts can be improved and identify the best abstract.

Next match each abstract with the associated comment A–G and write down the number of the abstract and letter of associated feedback (8H would indicate feedback H matches abstract 8).

Abstract 1) For a paper about personalised advertising V's privacy issues

This research paper is to introduce the issues of privacy behind the campaigns of targeted and personalized advertising. Discoveries of the underlying problems will be made from a literature review. Methodologies and concepts of will be identified and examined in order create a solution. The closing section of this paper concludes that businesses should take on the responsibility to inform the consumer and prevent violations in order to prevent negative reaction and protect business interests.

Abstract 2) For a paper about Vibration problems in Hard Disc Drives

Vibration is a very huge factor affecting hard disk drives (HDD) due to the rotational movement of the spinning disk during usage. This paper describes an evaluation of current innovations to mitigating HDD vibration problem and also takes note of the methodology used to back up the claims made. Methods are then compared so as to recommend most effective solution to solving HDD vibration problem from both internal and external stand point.

Abstract 3) For a paper about fingerprint security systems

Biometric fingerprint security exhibits the use of unique human characteristics for the purpose of security. In fact, this kind of security measure is on top of the list for many of the users mainly due to its least false acceptance ratio as well as ease of use. This paper focuses on methods of biometric protection presently existing to see if these methods can be used on a laptop computer and how well the computer system will be function. Recommendations will be made regarding which is the best current method.

Abstract 4) For a paper about cloud computing systems

In this paper I have looked at different research papers that are looking in to ways that will improve the abilities of the cloud computing systems, this is a field of computing that at this current moment in time has the potential to become very important and key in the way that the computing is developed over the next coming years. Looking at new methods that are being devolved in the way of making everything virtual to reduce the bottlenecking in networks, to papers looking at how to improve the security when transferring files across from the old system to the cloud system. I have found that these research papers are going to be used to help the cloud computing improve.

Abstract 5) For a paper about Human facial recognition systems

Human facial recognition system is one of the imperative areas of research that is advancing, several techniques is been introduce to improve facial recognition system performance. This paper compares and evaluates three different techniques used to enhance facial recognition systems performance, these include:- fusing global and local Gabor features, Curvelete transform for 3D facial identification and ROI selection strategy. Analysis shows that by combining two of the most successful techniques will give enhanced performance. A real world application of these techniques is presented and based on this recommendations are made for further research.

Abstract 6) For a paper about the impact of ICT on travel behavior

This paper describes an analysis of current research on information and communication technologies and travel behavior. It strives to show how the era of ICT has greatly changed man's travel habits and social communication patterns. Other research papers supports this point of view though some disagree. I am of the view that work-related travel generally would be expected to be reduced by those who telecommute. Social life, on the other hand, requires human to human interaction where true emotions can be relayed and thus travel for thus is essential.

Abstract 7) For a paper about security in Cloud computing systems

Cloud computing is defined as a mode for enabling ubiquitous, convenient on demand network access to a shared proof of configurable computing resources that can be rapidly provisioned and released within minimal management effort of service provider interaction, (NIST, 2012). As with any other environment that deals with more clients hence more data, cloud environment is marred by security concerns such as denial of service, security key management etc. which then compromise integrity, availability and authenticity of data which calls for security techniques of all kinds to mitigate. In this paper we have looked at some few techniques which include encryption, intrusion detection systems and the Hadoop distribution file systems. Widjadja (2009) says encryption refers to encoding of data using an algorithm so that it is incomprehensible to any party in the event that data transmission is intercepted unless the key is known to enable decryption. An intrusion detection system is a piece of software or a physical appliance that monitors network traffic in order to detect unwanted activity and events such as illegal and malicious traffic, traffic that violates security policy and traffic that violates acceptable use policies (Wu, 2009). Hanson (2011) says HDFS as this security technique is usually referred to as, it is a highly fault tolerant system designed to run on low commodity hardware. Through the evaluation of this various techniques it has been concluded that more research can be done in the field of security of data in the cloud.

Feedback 3

Feedback for this activity will be provided with the feedback for the next activity.

> **Activity 4**
>
> Next match each abstract above with the appropriate feedback below (A–G) making a note of the number and letter – thus 8H would indicate feedback H matches abstract 8.

A) *This abstract talks about current technology not about research.*

B) *Neither the abstract nor the paper should present personal views, opinions or feelings as this one does. The abstract should explain what research* ***was*** *critically evaluated and analysed – not what it hopes to do. It should summarise the main conclusions in a way that leaves the reader with a desire to read the paper. It should not give the actual conclusions away as this one does.*

C) *This abstract is essentially OK though it could be more detailed – what innovations are considered? What methods are compared?*

D) *This abstract reads like an introduction, it should just summarise the work presented in this paper. Most of this abstract is therefore not relevant. Only one sentence in the middle of this talks about this paper. The conclusion at the end that more research 'can be done' is underwhelming – more research can always be done.*

E) *This abstract does provide a summary of this paper but is vague in the middle – what concepts/what methodologies/what possible solutions? Furthermore this gives away the specific conclusion and therefore gives the reader no incentive to read this paper.*

F) *The abstract finishes with an underwhelming statement and does not leave the reader feeling this paper achieves any conclusions of value. It is also written in a very personal style – avoid 'I'.*

G) *Excellent…detailed and clear summary of the work done. Makes it clear specific and detailed conclusions are reached without giving the actual detail of the conclusion away. This gives the potential reader a clear reason to read this paper.*

Feedback 4

The answer to this exercise is 1E 2C 3A 4F 5G 6B 7D

Abstract 5 is the best abstract for reasons provided in feedback G but abstract 2 is also fine.

The other abstracts:- use personal terms such as 'I', give the conclusions away, finish with underwhelming statements regarding the conclusions, or read far too much like introductions.

13.3 Summary

In this chapter we have seen how:-

- an abstract can end up looking more like an introduction.
- an abstract should be treated as a completely separate document,
- an abstract should summarise the work done in your paper and summarise the conclusions with enough detail but without giving the conclusions away.
- the abstract should be written after you have written your paper.
- an introduction can be written in the future tense…it is about what the paper hopes to achieve.
- an abstract is past tense…this is a description of work that is complete.
- writing a good abstract is important if you want a person to read your research paper.

You have also had the chance to practise your skills by evaluating previously written abstracts.

In the previous chapters we looked at how to write individual sections of a research paper:- the introduction, the body of the paper, the conclusions and the abstract.

You should hopefully now be in a position where you can put the skills developed into practise and write your own good quality paper.

14 Considering Research as Part of a Dissertation

Introduction

We have now considered all of the skills needed to write a good quality research paper and therefore this book is coming to an end. However one useful topic still remains untouched i.e. how to write a research chapter that is part of a large undergraduate dissertation.

This chapter will consider the differences between a research paper and a research chapter and give you some advice on how to deal with these differences.

We will also briefly consider other issues relating to research and its impact on an undergraduate dissertation.

While this chapter will discuss the issues and offer some advice this chapter will not attempt to develop any skills and therefore this chapter will not contain any activities or feedback.

Objectives

By the end of this chapter you will have an understanding of the two main differences between a research paper and a research chapter and have some ideas on how to address these differences.

You will also have an understanding of some of the issues that relate research and the evaluation of the project outcomes.

This chapter consists of 7 sections:-

1) The Similarities between a Research Paper and a Research Chapter
2) The Differences between a Research Paper and a Research Chapter
3) The Length of a Research Chapter
4) The Impact of the Research on a Project
5) Evaluating the Impact of the Research
6) Practical Projects Verses Research Projects
7) Summary

14.1 The Similarities between a Research Paper and a Research Chapter

Before we consider the differences between a research paper and a research chapter, that is part of an undergraduate dissertation, let us first consider the similarities.

- Both need to consider current research and be based on a good quality literature search (i.e. use journal and conference papers),
- Both need to do far more than just summarise the information read i.e. both need to present your reasoned analysis and your conclusions.
- In both it should be clear which parts present your summary of the work done by other researchers and which parts present your evaluation, your analysis and your conclusions.
- Both need therefore to evaluate the evidence and conclusions presented by other researchers.
- Both need to compare the different theories and methods proposed by researchers.
- Both need to consider the application of the theory (though there is a difference in this aspect of the work that we will consider shortly).
- Both need to end with a conclusions section that draws together all of the conclusions reached in the body of the paper or chapter.
- Finally in both each step of the analysis and reasoning should stand up to scrutiny by a sceptical reader.

From looking at the similarities you may see that all of the skills developed in this book are all applicable to the task of writing a research chapter i.e. the ability to

- find a cohesive set of good quality papers,
- write in appropriate academic manner,
- cite sources and present an appropriately formatted reference list,
- evaluate research evidence based on a good understanding of scientific principles and methods,
- compare theories,
- consider the application of the theory and
- present clear and well justified conclusions that make a real contribution.

The differences between a research paper and research chapter are by comparison very minor but still worth considering.

14.2 The Differences between a Research Paper and a Research Chapter

There are only two significant differences between a research paper and a research chapter:-

1. A research chapter is usually longer than a research paper and this has a small impact on the written work.
2. A dissertation usually describes a project of some sort and in a research chapter the conclusions should feed into this project. This has an impact on parts of a research chapter and also has an impact on the final evaluation of the project.

14.3 The Length of a Research Chapter

As the length of a research chapter can be significantly longer than a research paper and this can have an impact on the way it is written.

Firstly the length of a research chapter may mean there is scope for a wider literature search and allow for a slightly longer and more detailed description of the research…Both of these can be improvements but both require care.

When writing a research paper, as the word limit is often constrained, it requires real skill to keep the descriptive sections as short and relevant as possible to allow as much space as possible for your evaluation and reasoned argument.

Providing longer and longer descriptions does not make a research chapter better. Remember the real contribution you make is where you present your evaluation, your analysis and your conclusions. Unless these sections also become better then you have not taken advantage of the looser restrictions on word length.

Worse still if you waffle, repeat yourself or spend too long presenting basic information then you can actually be making things worse.

Of course by extending the literature search you are extending the scope for your analysis giving you chance to present an even stronger evaluation and stronger set of conclusions and this can be excellent.

The length of the research chapter, and in particular the length of the dissertation also requires some thought given to the overall structure and to 'levels of abstraction'. This may well require more use of sub sections and even sub-subsections.

14.3.1 Levels of Abstraction in a Research Paper

A research paper is short and relatively simple to structure and yet it still exhibits levels of abstraction.

Levels of Abstraction in a Research Paper

The introduction to the research paper should explain the issues and overall concepts without presenting any detail or complex analysis. This discussion is presented at a high level of abstraction that allows the reader to grasp the concepts to be covered in more depth later…much like the first chapter of this book did.

The body of the paper delves into the fine detail and presents complex analysis and specific conclusions which, with the help of the introduction, the reader should be able to follow.

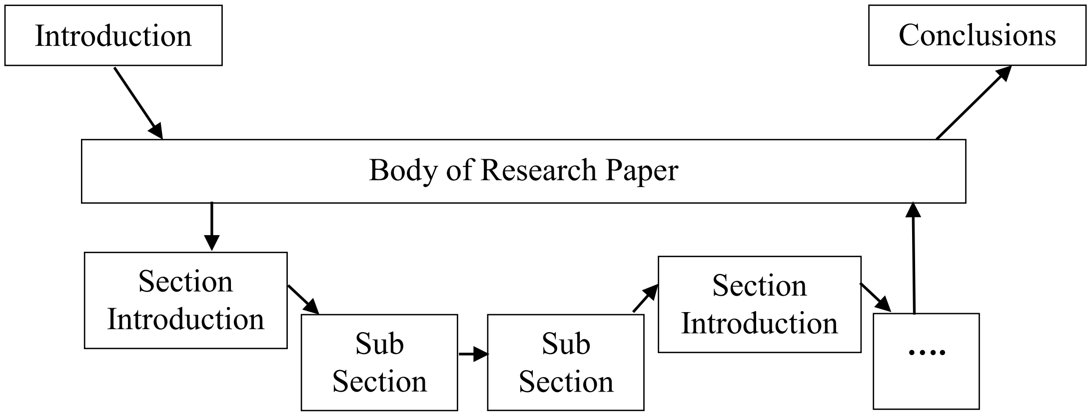
The conclusions section summarises the conclusions. This frees the readers mind from the complex detail and allows them to consider the relevance and overall implications of the analysis and conclusions.

Thus even in a short research paper levels of abstraction are important to aid the reader.

14.3.2 Levels of Abstraction in a Research Chapter

As a reach chapter is longer than a research paper it is likely to have subsections and even sub-subsections i.e. even more levels of abstraction.

Levels of Abstraction in a Research Chapter



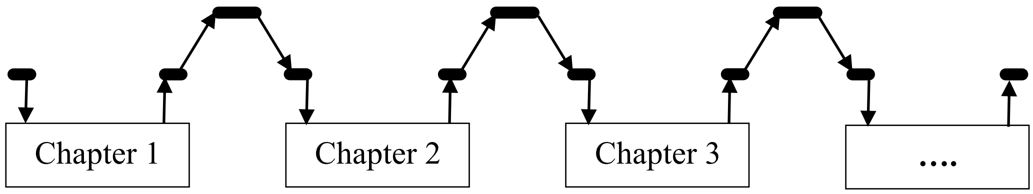
The greater the depth of the chapter the greater is the opportunity for the reader to struggle and forget the overall aims of the chapter as explained in the introduction.

With subsections and sub-subsections, where the reader is expected to delve ever deeper into the topic, it becomes even more important to present a good introduction and to properly introduce each subsection. The conclusions at the end, which present an abstract summary of the conclusions reached in the body, becomes even more critical as they allow the reader to appreciate the conclusions at a higher level and consider the impact of these without concern for all the detail and justification.

14.3.3 Levels of Abstraction in a Dissertation

A dissertation doesn't go any deeper than the deepest chapter so it doesn't really have many more levels of abstraction but it is longer and with that length there comes an even greater opportunity for the reader to get lost.

Levels of Abstraction in a Dissertation



When the reader is buried in the depths of one chapter not only will they struggle to remember what the overall aims of the chapter are they will struggle to remember what the purpose of this chapter is within the dissertation as a whole.

Essentially there is one extra level of abstraction that is required. The project and the dissertation as a whole must be explained. Thus the first chapter becomes an introduction to the project, and an introduction to the dissertation, and should cover:-

- The reason for the project,
- The aim of the project
- The detailed objectives,
- Any significant limitations
- The plan of action and
- The dissertation structure.

An important part of this introduction is the need for the research chapter and its potential impact on the project. This allows the reader to gain a most abstract and simplified understanding of the research and the reasons for doing this research.

This introduction helps the reader grasp a high-level, abstract, understanding of the purpose of the project as a whole and an abstract understanding of each chapter.

The final chapter will often summarise and reflect on the project conclusions and help the reader by giving them an abstract high-level view of the project outcomes, the successes and failures and their significance.

Additionally link sentences, at the start and end of the chapters, will help the reader by reminding them how far they have progressed through the dissertation and remind them what comes next.

14.4 The Impact of the Research on a Project

Earlier we described two key differences between a research paper and a research chapter.

One of these was the length of the research chapter and we have considered the impact of this on its structure and the need for chapter and section introductions. We have also gone further and considered the impact of the length of the dissertation.

The other difference is perhaps more significant. When a research chapter is part of a dissertation the conclusions are usually expected to have an impact on the practical work.

The research chapter should end with specific conclusions about what theories will be used in the project and what will be rejected. The potential impact of the research should be made clear in the research chapter's conclusions.

As we have already discussed there are three significant ways you can analyse research and reach meaningful conclusions:-

- Evaluate the evidence and researchers conclusions to determine which conclusions are valid,
- Compare the research theories to determine which are best,
- And consider how well those theories will work under real world conditions.

When writing a research chapter the first two of these are unchanged but the third should be different.

If undertaking an undergraduate project you should also consider the application of those theories for your specific project. This should lead to specific conclusions about what theories you will accept and implement and what theories you will reject.

You can still consider how well those theories will work under real world conditions and in doing so reach meaningful conclusions that will apply to other projects.

You can also consider how well the theories would apply to your project while assuming your project is not constrained by time, resources or by your abilities. In doing so you can reach conclusions about which methods would work best for your project if it was being done under ideal conditions.

Of course projects are often not done under ideal conditions: – your time will be constrained, you may not have access to all of the data you would like, your abilities to implement some methods may be limited.

Given the constraints you are working under it is perfectly normal to identify the methods or theories that would work best under ideal conditions and then explain which would work best for you given the constraints you are working under.

Thus towards the end of your research chapter you should therefore describe aspects of your project and to consider the impact of the theory on your planned practical work and reach specific conclusions accordingly.

By considering the application of the theory to your project, with and without constraints, you can at the end evaluate what impact the theories had on the project outcomes.

14.5 Evaluating the Impact of the Research

One important aspect of any significant project is to evaluate the outcomes. Much like a researcher needs to present clear, accurate and unbiased evidence in support of their conclusions you could be expected to collect evidence to support your claims regarding the outcomes of an undergraduate project.

This does not just mean collecting evidence on what worked well but also collecting evidence on what did not work well.

The nature of this evidence will depend very much on the practical work you may have undertaken:-

- If you have developed a physical artefact, e.g. a prototype car engine, you can test the physical properties of this,
- If you have developed an intellectual artefact, e.g. a management plan, you can get feedback from the management and staff it will affect. You can also estimate the cost and benefits of implementing that plan.
- If you are developing a software product, e.g. software to predict the weather, you can test its accuracy. You can also get feedback from users on its usability etc.

Thus whatever the practical outcomes you can evaluate the successes and failures of your project and make recommendations based on this evidence.

However as well as getting feedback and evidence on the practical outcomes you should also consider the impact of the research on your project.

Getting real evidence to show the impact of the research could be impossible but a detailed and personal reflection can be very worthwhile.

In the research chapter you considered the potential impact of the theories and decided what theories you would take forward…at the end of your project you can look back and consider if those decisions were the correct decisions.

If someone else was doing a similar project next year would you recommend the theories you tried to implement? Or would you now recommend something different entirely?

Evaluating the impact of the research is an important part of evaluating the project outcomes.

14.6 Practical Projects Verses Research Projects

Finally it is worthwhile considering the differences between practical projects and research projects. While many undergraduate students undertake practical projects others undertake research projects.

Many undergraduates undertake projects where the ultimate aim is practical. For example to develop a strategic plan for a specified company or to develop some software for a client.

Practical projects may not require research and yet an undergraduate maybe expected to learn from current research and apply the new theories to their project. If this is a project requirement then the research aim becomes an important subsidiary aim of the project and thus a current research theories will need to be considered and evaluated.

However some students undertake projects where the ultimate aim is not to develop an artefact or a product for a client but the ultimate aim is to do some research…For example a student could do some experiments to test different security protocols reaching appropriate conclusions…conclusions that could be published in a research journal.

In projects such as this the student is doing primary research and, while primary research was not the focus of this book, some of the theories covered in chapter 4 and 6 may prove helpful.

It is possible that a research project will require an artefact, for example you may develop a network simulation which will be used to test different security protocols. While artefacts like this may be necessary for the experiments they are in the end throw-away products.

For research projects evaluating the project outcomes then becomes more about evaluating the experimental work done to ensure the results are accurate, robust and free from bias etc i.e. evaluating the quality of the science. Evaluating the artefacts becomes far less important.

14.7 Summary

In this chapter we have considered research as part of an undergraduate project. Thus we have considered the differences between a research chapter and a research paper.

We have seen the many similarities between these and thus seen how the skills developed in this book apply to both.

We have seen how the a longer research chapter, and the length of the dissertation as a whole, requires us to understand the need to present different levels of abstraction thus,

- in chapter 1 it is important to present a clear introduction covering the need for the project, the project aim, the project objectives, the need for research, any limitations, the plan of action and dissertation structure.
- it is important to introduce chapters and sections
- link sentences between chapters are helpful
- the conclusions section helps the reader to understand the conclusions and their impact without concern for all the detail.

We have seen how the research should have an impact on the project and because of this:-

- the research chapter should consider the application of the theory to the specifics of the project reaching appropriate conclusions regarding which theories should be implemented and which should not,
- additionally as well as evaluating the practical outcomes of the project we should evaluate the impact of the research.

Finally we considered the differences between practical projects and research projects and for research projects considered how the project evaluation should really present an evaluation of the experimental work conducted to ensure its scientific validity.

15 In Conclusion

In this book we have covered a lot.

We started in Chapter 1 by dispelling the misunderstanding that research is about reading and finding out known facts. We learned that knowledge is true, justified belief and learnt a simplified scientific process. We have also learnt about good quality research sources.

In Chapter 2 we considered how research is changing our world and how you could make a contribution to this.

In Chapter 3 we learnt how to find a cohesive set of research papers, how to use several resource discovery services, including IEEE Xplore and Google Scholar, and we learnt how to choose an appropriate title for a research paper.

In Chapter 4 we looked at research methodology, learnt about scientific principles and research criteria. We learnt about the null hypothesis, why data used to generate a hypothesis cannot be used to test a hypothesis and we learnt about different ways a hypothesis can be tested including the use of double blind trials.

In Chapter 5 we learnt how to analyse the contents of a research paper and learnt that not all good quality papers are appropriate for our needs. We also looked at papers that used varied forms of research evidence (a comparative study, making and testing predictions based on the theory, experiments in a simulated environment and a mathematical or formal proof).

In Chapter 6 we expanded our knowledge of research theory by focusing on experiments and experimental design. This is important if we are to evaluate the work of other researchers. We looked in detail at different types of experiments:- Controlled, Natural, Case Study and Action Research and we have considered when/where to use these.

In Chapter 7 we focussed on bad science and the need for critical evaluation. We saw that critical evaluation does not mean to criticise. We looked at numerous ways research methodology can be flawed including:- Confounding Variables, Complexities with Comparative Studies, Badly Randomised Groups, The Order Effect, The Placebo Effect, Correlation/Causal Confusion, Surrogate Outcomes, Data Not Cleaned, Poor Data Collection and Biased Data. We considered how the discussion of results can be flawed and considered how, even if a methodology is sound, conclusions can be flawed. We also looked at the issue of False Positives and False Negatives.

In Chapter 8 we considered the issue of plagiarism and we learnt how to correctly cite sources and provide a properly formatted reference list. We also considered the difference between a reference list and a bibliography.

In Chapter 9 we practised academic writing skills in the specific context of writing a research paper.

In Chapter 10 we looked at the process of drafting a research paper and considered the need to start our writing quickly and continually refine our work. We looked at how to break the task of writing a research paper into smaller simpler steps (define the general structure, write a rough introduction, add descriptive sections, add evaluation sections, draft the comparative analysis and draft conclusions) and we considered how a critical friend can help.

In Chapters 11 to 13 we focussed on the different sections of a research paper:- the introduction, the body and conclusions and the abstract. We saw that the introduction was a funnel and how we could use less relevant papers. We looked at different ways to structure a paper. We looked at how other writers have considered evaluation, comparative analysis and applications of theory and we learnt how we can test the quality of a paper.

In Chapter 14 we looked at research being done as part of a larger undergraduate project and at the differences between a research paper and a research chapter.

Throughout this book were numerous activates and feedback to help you. If you have worked through each of these chapters then you have hopefully developed your research skills and your written skills.

It is a testament to your tenacity and willingness to learn that you have made it this far.

I hope you have found the videos informative and practical activities a useful learning tool.

Finally three excellent and complete research papers are provided in appendix 1. These demonstrate how the theories covered in this book can result in a complete research paper.

It is important to note that these were written by three ordinary students, two of them in their first year at University. These students were not geniuses they were just dedicated students who were keen to learn and willing to work hard.

If they can write an excellent research paper then so can you!
...and I do hope this book will help you do this.

Kind regards and best wishes for the future.

Simon Kendal

Appendix 1) Three Research Papers

Introduction

In this appendix are three research papers, all of which were written by undergraduate students and all of which have been published and reproduced here with the kind permission of the authors.

They are:-

'An Evaluation of Information Hiding Techniques Using Image Steganography' by Muhammad Hussaini

'Current EMG Pattern Recognition Research Aimed At Improving Upper Limb Prosthesis Control' by Molly Sturman

'Positive and Negative: Effects Video Game Use Can Have on Personality Development' by Shaun Watson

Hopefully by looking at these papers you will see how the techniques covered in this book can be applied and in particular how each of these papers make a valid contribution to knowledge by evaluating research and comparing the theories discussed to reach their own well-reasoned conclusions.

Two of these papers were written by first year students who, when they started, had no knowledge of research and who had never read a research paper. If these students can learn to find, read and evaluate research then so can you.

1.1 'An Evaluation of Information Hiding Techniques Using Image Steganography' by Muhammad 1Hussaini

An Evaluation of Information Hiding Techniques Using Image Steganography

Muhammad Hussaini

Abstract

Steganography has become the technique of choice for hiding secret messages in a cover media, presenting and transmitting it as a harmless piece of content, therefore making it hard to detect unlike encryption. This paper provides an adept evaluation of some of the prominent image steganography methods, showing their strengths, weaknesses and applicability, further conclusions were made regarding the effectiveness and otherwise of the techniques evaluated.

1 Introduction

Protecting the privacy of information for organizations, governments and individuals have become increasing challenging in recent times due to the increased use of computers and digital means of communication. Various methods of protecting information and privacy have been researched and developed, the most obvious being encryption and then steganography. Encryption differs from Steganography due to the fact that encryption is generally observable and arouses suspicion, while steganography aims at being un-observable and difficult to detect, this is achieved by hiding the secret message in unremarkable carrier media (Chanu et al 2012).

Image Steganography is achieved using either transform or spatial domain methods, in spatial domain the cover media and the secret message are both modified, this involves encoding at the Least Significant Bits of the image and also by transforming the image pixel blocks into 64 Discrete Cosine Transformation co-efficient and putting the pixels into groups, the image is transformed into a frequency representation from an image representation, the transform domain utilizes this method for embedding the secret data into the cover image that is transformed (Das and Tuithung, 2012), the LSB replacement technique is however vulnerable to statistical analysis (Ghebleh and Kanso, 2013).

Further research have therefore been carried out into developing more secure methods of image steganography such as that by Prabakaran and Bhavani (2012) which uses Discrete Wavelet Transform to achieve a high capacity steganography scheme that enables large size of secret data to be embedded into smaller sized cover images.

Raftari and Moghadam (2012) also claimed that by combining Integer Wavelet Transform and Discrete Cosine Transform which are both transform models, a more secure image steganography method was achieved based on results that showed good value of Peak signal to noise ratio (PSNR) in the secret image, an acceptable visual quality which leaves the secret data unnoticed, Mean structural similarity index measure (SSIM) and the Histogram error (HE).

The aim of this paper is to critically evaluate and analyze current research focused on developing more secure methods of image steganography, models and techniques used, conclusions and claims reached based on experiments carried out and their results.

2 Evaluation of Current Steganography techniques

Anastasia, et. al (2012) proposed a technique of achieving a robust image steganography using a high payload method and edge detection, where hybrid edge detector is derived by unifying the fuzzy edge detector and the sobel and the Laplacian filters for simplicity, this method does not compute the real edges in an image but distinguishes between the sharp and smooth areas of the image so as to hide more secret data bits into the edge pixels. In this method, as well as the secret message, two property files which contain information regarding extraction of the secret message are also encrypted using 3-DES with the secret key provided by the user during the embedding process.

Lena	Chen et al. method	Our method					
		Laplacian OR fuzzy edges			Sobel OR fuzzy edges		
		RNG with step 1,2,3	RNG with step 1,2	NO RNG used	RNG with step 1,2,3	RNG with step 1,2	NO RNG used
Capacity	10,662 (bits) 0.65 (bpp)	15,295 (bits) 0.93 (bpp)	20,356 (bits) 1.28 (bpp)	30,987 (bits) 1.89 (bpp)	15,213 (bits) 0.93 (bpp)	20,490 (bits) 1.25 (bpp)	30,811 (bits) 1.88 (bpp)
PSNR	47.1	46.88	45.88	45.12	45.91	46.88	44.45

Figure 1. Comparison of test result from the proposed method by Anastasia et. al. (2012) and the method proposed by Chen et. al. (2010).

The experiments carried out to test this algorithm used the same images used by Chen et. al. (2010) for their image steganography scheme, this is used in order to enable seamless comparison of both techniques, although they used colored images while Chen et. al. (2012) used grayscale images. Factors used for comparing the two schemes included the hiding capacity in bits divided by three, the peak signal to noise ratio (PSNR) is also measured, a higher value of PSNR is considered better. Figure 1 below shows the result of comparing this method and that of Chen et. al. (2010).

Based on the results presented above, Anastasia, et. al. (2012) claimed that there method which uses a hybrid edge detector together with the sobel and laplatian filters to enable embedding additional secret messages in the edge pixels outperforms the hybrid edge detection method proposed by Chen et. al. (2010).

The result of evaluating this method showed that colored variants of the image set used by Chen et. al. (2010) were used in the experiment, these image set are used in many other image steganography experiments, making it a good choice. The experiment is repeatable due to the fact that it is the most widely used for testing image steganography. The use of colored variants of the images in the experiment with the new method might not give an accurate representation of the performance when compared to the method of Chen et. al. (2010) which uses grayscale variant of the same images, the use of encryption as part of the algorithm may also cause potential issues with performance and may cause significant change in the size of the stego image as compared to the original cover image, testing the new algorithm with only one other method might also not give an accurate measure of its potential performance as compared to other current algorithms in the market and those proposed in current research papers.

Ghebleh and Kanso (2013) proposed an algorithm of implementing image steganography by hiding the secret message as binary in a pseudo-randomly chosen detail co-efficient of the cover image based on discrete wavelet transform and a 3-dimensional chaotic cat map. The algorithm also uses discrete wavelet transform to achieve robustness against image processing filters and steganalytic attacks, it also utilizes edge adaptability in order to hide more data in the edge pixels where it will be less visible to the human eye, whereas lossless extraction of the secret hidden message is achieved by using lifted discrete wavelet transform. The extraction process uses the same lifted wavelet transform used in the embedding process to find the detail and approximation co-efficient, this enables retrieving the hidden information from the exact pixels they were hidden in.

The experiment carried out by Ghebleh and Kanso (2013) was performed in order to gauge the performance of the proposed image steganography algorithm on the basis of its security, imperceptibility and feasibility. Randomization of the position of the stego-image which carried a secret message of size 2bpp and was embedded in the cover image ensured that a visual inspection of both the stego and cover image does not unveil the difference between the images. The histogram of both the cover and stego image was calculated, as well as the difference which shows that there is no significant difference between the two images as shown in figure 2 below.

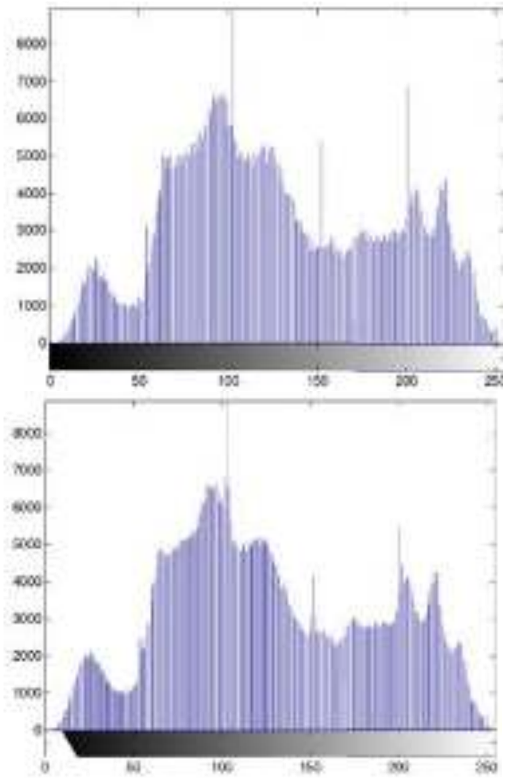


Figure 2. Cover media Image Histogram (Top),
Stego Image Histogram (Bottom) (Ghebleh and Kanso, 2013).

The experiments they carried out measured the image histogram, the similarity measures were also calculated and presented based on existing units of similarity measure – the mean square error (MSE), peak signal to noise ratio (PSNR), and the structural similarity index (SSIM). The results of the experiment was also compared with three (3) current transform domain based image steganography schemes by (Raja et. al. 2008), (Souvik and Gautam, 2012) and (Gandharba and Saroj, 2012), this were chosen due to the fact that they all used colored images for their experiments, this enabled direct comparison of these schemes with the proposed scheme. The comparison table is shown in figure 3 below.

Cover	Message		Proposed	Raja et., al	Souvik	Gandharba
Saturn (512 × 512)	Parrot (384 Kb)	PSNR:	52.298	45.03	-	-
		SSIM:	0.9982			
Lena (512 × 512)	Random (38 Kb)	PSNR:	61.128	–	34.817	–
		SSIM:	0.9989	–	0.9834	–
Lena (512 × 512)	Random (125 Kb)	PSNR:	56.135	–	29.339	–
		SSIM:	0.9997	–	0.9743	–
Lena (512 × 512)	Random (116 Kb)	PSNR:	56.453	–	–	40.67
		SSIM:	0.9997			

Figure 3. Comparison of the results of Proposed algorithm (Ghebleh and Kanso, 2013) with that of Raja et. al. (2008), (Souvik and Gautam, 2012) and (Gandharba and Saroj, 2012).

Ghebleh and Kanso (2013) concluded that their proposed algorithm is superior to the algorithms it was compared to, they also presented evidence that showed they achieved a good imperceptibility measure based on the two units of similarity measure, which are PSNR and SSIM index, as well as having a high secret key sensitivity.

The research carried out by Ghebleh and Kanso (2013) was rigorous due to the fact that there proposed method was tested against attack from different steganalysis methods which use LSB replacement, the methods include the Chi-Squared Test (Westfeld Andreas, 2000), Weighted-stego analysis (Fridrich and Goljan, 2004) and Sample Pair analysis (Dumitrescu et al, 2003).

Results have shown that the method is effective against these techniques of steganalysis, although more test will need to be carried out to ascertain its strength against other forms of attack such as statistical steganalysis which are also very popular. The choice of 3D Cat map is applauded due to its sensitivity to even small changes in secret key used. Although, the application of a transform domain technique and the randomness of the choice of bits where data is hidden proves effect, the transform domain is known to cause reduction in the quality of stego-image produced.

3 Comparison of current Steganography techniques

The methods of image steganography described above are similar because they both used the least significant bits (LSBs) of the cover image as well as utilized edge detection in their own different ways, both methods could benefit from the techniques used by the other. The edge detection method used by Anastasia et. al (2012) enabled the hiding of larger secret messages, this can be useful in Ghebleh and Kanso's (2013) method which uses a 3D cat map to find random bits for storing secret message without considering the size of the hidden data, thereby enabling it to hide larger sizes of secret messages. Another significant difference between the two methods is in the way they store information about the bits where the secret data is hidden in the cover image, Anastasia et. al (2012) stored this information in two information files which are encrypted using 3-DES with a secret key provided by the user during the steganography process, these files are required during the message extraction process, where as Ghebleh and Kanso (2013) regenerates the 3D cat map used during the embedding process, this gives the exact information needed to recover the secret message from the bits they were hidden in, this method could be beneficial in Anastasia et. al (2012) method by eliminating the need for encryption which may cause performance lags.

Both Anastasia et. al (2012) and Ghebleh and Kanso (2013) used colored images in their experiments. The methods for testing the strengths of steganography methods rely on the SSIM, HE value and PSNR, both methods have carried out calculations to determine its strength based on these values, this also enables seamless comparison with other methods. To compare the methods evaluated above, both used colored JPEG images although Anastasia et. al (2012) compared there results with another experiment which uses the same images but of grayscale variant, this may not give a realistic comparison of performance and effectiveness.

Ghebleh and Kanso (2013) on the other hand compared there results with three different other method which use the same steganography technique and also uses colored images, they also carried out the same tests as those three and compared them to their own results, this shows quite a bias free methodology. Generally, both methods could complement each other.

4 Conclusions

Steganography is a technique of hiding secret data in a cover media, mostly images. A lot of research have been carried out towards both producing more effective methods of steganography as well as countering it. The research by Anastasia et al (2012) focused on hiding a larger size of secret message in the stego-image, this was achieved by using a hybrid edge detection algorithm with the SOBEL and Laplacian filters, although the main objective was achieved as shown by experiments, its conclusion based on comparison with the method of Chen et al (2010) may not have shown an accurate representation of the performance due to the fact that they used the same set of images but of colored variant. The use of encrypted information files as part of the steganography process may also cause some significant performance issues depending on the size of secret message and the cover image as well, since encryption is a resource intensive process and rivals the essence of steganography which is to remain unnoticed.

Ghebleh and Kanso (2013) proposed a steganography method which utilizes the irregular output of a 3 Dimensional cat map to embed the secret data in randomly chosen bits of the cover media, the experiment was rigorous and was tested against steganalytic methods which targeted LSB based steganography schemes, although it was not tested against other steganalytic attacks such as statistical attacks which are very popular.

The choice of using 3 dimensional cat map to provide randomness of the bits where the secret message is hidden is applaudable, the 3 dimensional cat map's sensitivity to even slight changes to its secret key makes it unique. The method is based on the transform domain technique of embedding which has been proved to be effective, but tends to produce a reduced quality of final stego-images.

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1.2 'Current EMG Pattern Recognition Research Aimed At Improving Upper Limb Prosthesis Control' by Molly Sturman

Current EMG Pattern Recognition Research Aimed At Improving Upper Limb Prosthesis Control

Molly Sturman

Abstract

Research into the application of electromyogram (EMG) pattern recognition is showing that it is essential in the intuitive and natural control of upper limb prosthetics; however, clinically it is not often used due to its limitations. In this paper, the methodology of three different pattern recognition classification methods will be compared, evaluated and analysed, these include: single LDA classification, simultaneous parallel approach and conditional parallel approach. The purpose is to investigate the advantages and disadvantages of each of the approaches. Recommendations will be made from the results for further research and comparisons regarding the uses of each technique and their real life application.

1 Introduction

The application of electromyogram (EMG) pattern recognition in the control of upper limb prosthesis has been a popular topic of research over the last five years. However, it is not clinically used due to its limited dexterity (Scheme, 2011) and EMG recordings can become unreliable over time (Zhang et. al. 2013) making the limbs not suitable for everyday situations. Hargrove, L.J. et. al. (2013) conducted research into increasing the number of EMG channels to improve the accuracy of the pattern recognition system without needing more electrodes. Amsuss et. al. (2014), Scheme (2011) and Zhang et. al. (2013) provide research into making prosthesis more clinically viable and allowing the user more intuitive control.

EMG pattern recognition could offer the user more control of the prosthesis, including allowing them to gain more movement and control of the force they put into their movements, as it will learn how the EMG changes depending on the user's intent (Khokhar, Z. et. al. 2010).

This research paper will focus on studies that have been carried out on using EMG pattern recognition to improve upper limb prosthetics. The paper will discuss different classification strategies, results of the research and critically evaluate the strength of the outcome. Conclusions will be made throughout the paper regarding how each method will affect the prosthesis and then finally summarized at the end. The primary object of these papers was improving the dexterity of upper limb prosthesis. This paper uses the research of those that focused on improving the pattern recognition and artificial intelligence by looking at the classification errors and processing time.

2 Background

There are three types of pattern recognition methods which will be evaluated, and these shall be referred to as single LDA classification, simultaneous parallel classification and conditional parallel classification.

Young, A. et. al. (2013) explains that with the conditional parallel approach each classifier makes an assumption that a discrete motion is active. The parallel approach also makes an assumption: "a set of features characterizing the EMG signals repeatedly describes a state of muscle activation and maps it to one degree of freedom" (Wurth, S.M., Hargrove, L.J. 2013). However, both studies show that this assumption may not always be correct. On the other hand, Single Linear Discriminant Analysis does not rely on any assumptions or previous knowledge.

3 Linear Discriminant Analysis

Chu, J. et. al. (2007) conducted a study comparing a Linear Discriminant Analysis (LDA) approach to three other feature projection methods – Principal Components Analysis (PCA), Non Linear Discriminant Analysis (NLDA) and Self-Organizing Feature Map (SOFM) – to try to determine whether this was a useful method in classification accuracy in a short time span. It was initially decided that the processing time should be less than 300ms with a 125ms window increment to avoid delays.

The study focused on nine types of hand motions, using four surface electrodes to measure the EMG signals. The hand motions assessed were: "flexion and extension of the wrist, radial and ulnar flexion of the wrist, pronation and supination of the wrist, opening and grasping of the fingers, and relaxation." (Chu, J. et. al 2007). The study was conducted in twenty sessions per participant using ten participants. The motions were randomly ordered in each session and the participants were asked to perform them for five seconds each.

The results table Fig. 1 shows the processing time to the millisecond of the different processes and the total processing time for the movement to be completed. The total processing time was 97ms which met the requirements and proved no obvious delay to the user.

Processes	Processing time [msec]
Wavelet packet transform	30
Linear discriminant Analysis	2
Multilayer perceptron	5
Myoelectric hand control	40
Others	20
Total processes	97

Fig. 1 Average Processing Time For Real Time Pattern Recognition (Chu, J. et. al. 2007)

Fig. 2 shows the classification success rate percentage and the processing time for LDA, PCA, NLDA and SOFM. Whereas the NLDA has the highest success rate, the processing time was significantly higher than the LDA, which had only a 0.5% difference in the success rate. Due to the processing time of the NLDA the conclusion was drawn that the LDA performed better, as the NLDA did not meet the requirements of the processing time being less than 125ms window increment.

	LDA	PCA	NLDA	SOFM
success rate [%]	97.4	95.9	97.9	96.2
processing time [msec]	2	2	[illegible]	[illegible]

Fig. 2 Average Values of MLP Classification Success Rate and Processing Time (Chu, J. et. al. 2007)

The research was focused and carried out well. The paper explains the method used well and has quite a thorough description. The motions assessed were relevant and commonly used, and the order of the movements was randomised. However, there was no reference in the paper as to how the motions were randomised.

The study concludes that the LDA method gave the user the ability to operate the prosthetic with a high success rate and a low processing time. The results confirm that the LDA meets both of these requirements, with a processing time of 2ms, leaving the total processing time as 97ms, which is well within the requirements. This reflects the conclusion that the LDA method, in an experimental setting, was the most appropriate method in this test.

Real life application, however, is a limitation of this study as the study concludes that more research will need to be done to make it more appropriate. The study was conducted assuming that the EMG signals came from a 'static contraction in a steady-state motion and fixed movement velocity in a transient-state motion' (Chu, J. et. al. 2007). This means that the study is difficult to apply to everyday tasks for an individual and therefore, requires further research.

The method used by Chu, J. et. al. (2007) compared the LDA method to three other methods. Hu, H. et. al. (2012), on the other hand, compared the study to five extended LDA methods, which could be used as further research into the area, although some of the classification methods do overlap. The types of LDA methods studied by Hu, H. et. al. (2012) may help to further the research by Chu, J. et. al. (2007) to improve its real life application.

4 Simultaneous Parallel Approach

Wurth, S.M., Hargrove, L.J. (2013) used on a strategy with two simultaneous parallel classifiers to create a more natural and intuitive upper limb prosthesis operation. This was compared to a sequential method to assess the advantages of simultaneous pattern recognition for prosthetics.

The study was tested on eight right handed people aged between 23 and 30. Six surface electrodes were placed equidistant around the forearm on the subjects. A real time single LDA was used as classification for the output into one of the motion classes to test the sequential pattern recognition. For simultaneous pattern recognition, two parallel classifiers were used; one for each degree on freedom. The difference between the sequential pattern recognition and the simultaneous pattern recognition was assessed with control strategy, target type and session as fixed factors and the participant classified as a random factor.

Fig. 3 show both of the methods tested for both discrete and combined tasks and rated on completion, overshoot and reaction time. The paper states that the results reflect the initial hypothesis that a simultaneous pattern recognition system will be more appropriate when participating in combined tasks.

	Discrete tasks (1 DOF)		Combined tasks (2 DOFs)	
	PR	*SPR*	*PR*	*SPR*
Completion (%)	99.75 ± 1.1	99.72 ± 1.08	96.79 ± 0.88	96.12 ± 0.88
Overshoot (%)	20.91 ± 1.35	10.23 ± 0.8	25.67 ± 1.25	11.34 ± 0.71
Reaction time (s)	0.62 ± 0.11	0.69 ± 0.17	0.65 ± 0.06	0.69 ± 0.22

$p < 0.01$

Fig. 3 Results showing the difference between simultaneous pattern recognition (SPR) as opposed to sequential pattern recognition (PR) in both discrete and combined tasks. (Wurth, S.M., Hargrove, L.J. 2013)

The research by Wurth, S.M., Hargrove, L.J. (2013) was explained thoroughly and conducted well.

These results show that there is potential for simultaneous pattern recognition to be a useful and appropriate method for multi – functional upper limb prosthesis. However, other methods would provide a much quicker reaction time and this is essential in creating an intuitive prosthetic.

Young, A. et. al. (2012), used an alternative hierarchal approach which was based upon using a parallel approach. This took a similar approach but built on it to create a more complex method that provided low classification errors.

They conclude that whilst the research is a good basis for further studies, it did not necessarily show that the simultaneous parallel approach was a more appropriate method than a sequential method. This conclusion is representative of the results and the limits to the research that was conducted.

5 Conditional Parallel Approach

Young, A. et. al. (2013), proposed a method known as the conditional parallel approach. It is an extension of a parallel approach which uses two simultaneous classifiers. They compared this to a regular parallel method and the LDA method to determine whether their method was an improvement on other methods for improving the degrees of freedom in upper limb prosthesis.

The study was conducted on three male non-amputee subjects and three female non-amputee subjects as well as two above elbow (trans-humeral) amputees who had undergone TMR surgery. All of the partakers were seated, un-restrained and were not given any feedback throughout the experiment. There were six pairs of electrodes places equidistant from one another around the circumference of the upper forearm for the non-amputee subjects and eight pairs of electrodes placed on the biceps and triceps for the amputee subjects.

Four degree of freedom classifications tests were carried out for the three classification strategies on the participants. The performance of the classification strategies was evaluated by the percent of incorrect classifications. Comparisons were made with classification error as the response variable, and the fixed factors as the classifier strategy, degree of freedom configuration and the number of channels. The participant was classified as a random factor.

The results in Fig. 4 show that for both two and three degree of freedom configurations the LDA and conditional parallel method performed significantly better than the parallel method. The conditional parallel performed a lot better than a single LDA classifier with a two degree of freedom configuration and slightly better using a three degrees of freedom configuration.

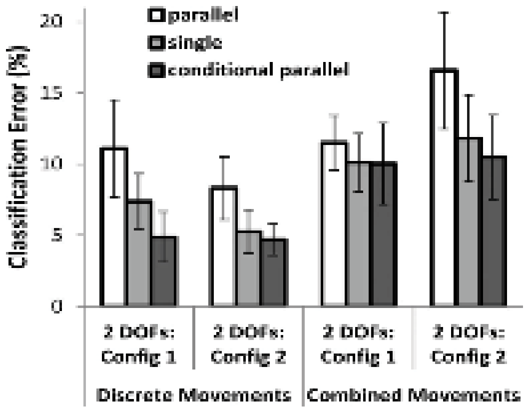

Fig. 4 Classification Errors for the three different methods for the varying degrees of freedom. "Configuration 1 is wrist and hand DOFs and configuration 2 is rotation and hand DOFs. Results are shown for six channels of EMG and are an average of six subjects. Error bars show ± 1 standard error of the mean." (Young, A. et. al. 2013).

The research conducted by Young, A. et. al. (2013) was a well thought out and in depth approach. The study was tested on both amputee and non – amputee participants which helps to confirm that the method will be applicable in the real world. The participants were all treated the same, ensuring that the results were not affected by position of the subject. as the amputee subjects had undergone TMR surgery, the placement of the electrodes was appropriate.

This study did not test online control; however, there have been many other studies, such as Hargrove, L.J. et. al. (2011), which gives evidence of a strong correlation between online controllability and classification accuracy.

The conclusions drawn in this paper show that the conditional parallel approach is aimed at trans-radial amputees, although future research could look into using similar techniques for TMR subjects also. The paper also states that the research could be used to develop a deeper look into using simultaneous pattern recognition and the conclusion that a conditional parallel approach has few classification errors than the parallel approach appears to be justified.

6 Comparison of Pattern Recognition Techniques

The research evaluated throughout this paper all had an aim to improve upper limb prosthesis using EMG pattern recognition. The methods all had advantages and limitations stated in their conclusions and results allowing comparisons to be made for a recommendation for the most appropriate method.

The conditional parallel approach had advantages of low classification errors, as the results by Young, A. et. al. (2013) show that they had lower errors in both discrete and combined movements. This is a significant advantage as low classification errors will provide fewer problems for the user.

LDA does also have a low classification error, shown both by Young, A. et. al. (2013) and Chu, J. et. al. (2007), although not as low as the conditional parallel approach. It does, however, have a very quick processing time which will provide a more intuitive prosthesis for the user. Research into methods extending from LDA and improving the real life application may make it a more suitable option, however.

The research by Wurth, S.M., Hargrove, L.J. (2013) showed that, whilst simultaneous pattern recognition had advantages of high completion percentage and lower overshoot percentage over sequential pattern recognition in combined motions, there was the disadvantage of it having a slower performance in the discrete motions, whilst being equally efficient otherwise. The simultaneous approach is inferior to the other methods analysed as it shows no significant or consistent advantages in improving upper limb prosthesis.

The results all show that all three methods analysed have limitations, such as real life application or online control, which require further study to allow fully intuitive results.

7 Conclusions

In this paper, pattern recognition methods of classification to improve upper limb prosthesis have been analysed and evaluated. A literature review has shown various ways that different researchers have attempted to improve the dexterity, control and intuitiveness of prosthetics.

A comparison of the research appears to prove that, although the parallel approach does have some advantages, both the conditional parallel and the LDA are superior methods to the parallel approach in terms of classification accuracy and processing time. This shows that in an effort to improve upper limb prosthesis the parallel approach would not currently be recommended.

From the research reviewed, the recommendation could be made that the conditional parallel approach will provide the lowest classification errors for both the discrete and combined movements which will be a positive argument for the user. Research should be conducted into using both the LDA method and the conditional parallel method to improve the processing time to create an upper limb prosthetic with full, immediate functionality.

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1.3 'Positive and Negative: Effects Video Game Use Can Have on Personality Development' by Shaun Watson

Positive and Negative: Effects Video Game Use Can Have on Personality Development

Shaun Watson

Abstract

Previous research has found that consistent video game use can have a string of effects on an individual in terms of personality, a large proportion of which cover the negative impacts. Research has shown that certain video games can increase cognitive abilities, increase social activities and influence various emotional personality traits such as aggression, joy and acceptance among various other emotions in adolescents particularly. The purpose of this article is to examine various aspects of personality development due to video game use and show both the positive and negative sides of these aspects. Considering both sides of this matter is important to maintain a well-balanced argument and in turn to produce useful recommendations and conclusions. Finally, to better understand the effects video games have on an individual's personality, it is vital to consider a range of aspects in relation to personality.

1 Introduction

In recent years video games have become a major part of almost all children's and adolescent's lives, with 97% playing for at least one hour a day in the United States (Granic, I. et.al. 2013). A large proportion of the research done into the field of video games tends to focus on the negative impacts they have and what problems they cause and amplify such as the research done by (Markey, P.M. and Markey, C.N. 2010). Although this research is all valid and reasonable, a more balanced argument is needed which compares both negative and positive impacts of consistent video game use. In no way does this imply no research has been done into the positive side, research done by (Granic, I. et.al. 2013), (Durkin, K. et. al. 2013) and (Velez, J.A. and Ewoldsen, D.R. 2013) all show various positive elements of video game use. The aim of this paper is to place the positive side of "gaming" next to the negative side in terms of the effects it has on personality development mainly in adolescents and then compare the two sides with evidence to back up the arguments shown. This paper will focus strongly on the effects and changes that video games can have on personality in terms of skills, senses, abilities and traits of an individual. To conclude by offering some recommendations and backed up conclusions based on solid evidence. These recommendations will provide a basis for further research and possibly impact on design choices within future video games.

2 Aspects of Personality Development

The following research will be split up into four different sections which will account for the four aspects of personality development strongly linked to video game use: Cognitive, social, emotional and educational aspects. Although personality is a broad subject and could be split into many different categories, the four previously mentioned coincide with video game use.

2.1 Cognitive Effects

"Contrary to conventional beliefs that playing video games is intellectually lazy and sedating, it turns out that playing these games promotes a wide range of cognitive skills" (Granic, I. et.al. 2013). The cognitive effects tend to be the most often considered effect of video game use; this is particularly true in terms of educational games. "From a psychological perspective, the potential of games to support and extend cognitive development is of particular interest." (Durkin, K. et. al. 2013).

K. Durkin et. al. (2013) looked at various experiments that have been conducted which try to expose the cognitive changes due to video game use. One of these studies measured adolescents suffering from ADHD who were aged 6 to 12 and a comparison group of boys with TD, and were tasked with playing a relatively straight forward game, Point Blank and a slightly more complex one, Crash Bandicoot. Specifically, participants were tested in conditions where they had to maneuver a character along a route and not touch the side and in the latter, they had to do the same but also had to perform and action at a certain point (spin to destroy objects). Results of the former proved similar among both groups but the boys with ADHD performed poorly at the latter and kept performing the action at incorrect times. They concluded that working memory deficits in these children alter when confronted with different tasks.

The experiment could easily be recreated again if needed, although only a small group of boys, the results are reliable as the conditions were fair and accurate as all taking part in the experiment were under the exact same conditions and all participants were within a narrow age group therefore we can rely on this evidence. Overall this study shows that certain tasks in video games can have an effect on cognitive functions within the brain such as working memory and attention.

While it seems apparent that children become proficient at specific skills in video games, it appears that they generally keep video game play separate from other areas of life, so it is not clear whether these preferences and skills transfer to other contexts. (Hamlen, K.R. 2013) This statement raises the question of why adolescents play video games and what is their motivation which in turn raises the question of why do people cheat at video games and what affect can cheating have on their personality as a result.

A study conducted was a qualitative study with three teenage boys. (Hamlen, K.R. 2013) The data was collected via interviews with analysis, these interviews focused on the participant's background, details of the participant's background with cheat codes and participant's views on cheating in video games and academically. From this they concluded that those who choose to avoid the effort of completing the game tend to be those who are more likely to cheat in academics.

This experiment could not be done by anyone else as the questions that were asked in these interviews are unknown and it would strongly depend on the analysis of the individual (the interviewer). Although the topics of the questions are suitable as it is plausible that they could be used to see a correlation in cheating at video games and also in everyday life, this experiment can't be relied upon because of the lack of information given.

2.2 Social Aspects

The social side of video gaming is often overlooked by the press and general public. They tend to see video gaming as an antisocial pastime and link it strongly to loneliness and depression although there are some who see it as the complete opposite of this. Socializing is arguably the most important factor for the development of an individual's personality; interactions with others can define various characteristic through adolescence. Interactions can mold the opinions of a person and the outlook they have on various topics therefore can have an impact on personality. Social gaming refers to playing with other players either competitively or cooperatively (Velez, J.A. and Ewoldsen, D.R. 2013).

An extensive study conducted that delved into the social side of gaming involved various experiments. One of which was very detailed and planned extensively. The experiment involved thirty six students (13 women, 23 men) who were randomly assigned to one of two game conditions (prosocial game vs neutral video game) the ages ranged from 19 to 43 years old. Tetris was used for the neutral video game and City Crisis was used for the pro social game. After participants played the game for 8 minutes, one of two experimenters left the room and informed a male confederate to enter in the role of a lonesome ex-boyfriend of the other experimenter. The actor was instructed to act very aggressive to the experimenter and get frustrated, as a measure of Prosocial behavior, it was measured if the participant intervened or not. The minimum requirement was that the participant spoke at all, if this occurred, the actor immediately left the room, if not then the other experimenter reenter and asks the actor to leave still in character.

Ten out of the 18 participants who played City Crisis intervened with the situation compared to only 4 out of the 18 who played Tetris meaning 56% of the participants in the prosocial video game condition helped, whereas only 22% in the neutral video game condition helped. They concluded from this that video games had an effect on the decision making process of the participant's and that playing a prosocial game increased the chances of compassionate behavior by up to three times. (Greitemeyer, T. and Osswald, S. 2010)

The study could very easily be recreated again with the information given; all conditions involved were very thorough and detailed. The students were randomly assigned and there was also a mixture in gender among the participants. The participant was completely unaware of what was about to happen in the experiment and they were given a questionnaire at the end to mask the real experiment. None of the participant's had any suspicions that the harassment scenario was not real. Therefore this study is perfectly valid and can be relied upon.

2.3 Emotional Aspects

Playing video games can have various different effects on an adolescent; one of these effects can be emotional effects. Emotions play a huge role in the development of personality, emotional tendencies can influence decision making and how others react and interact with an individual (e.g. if an individual is prone to anger) which can alter behavior.

The most controversial emotion that video games are accused of incurring is aggression. Various studies have been done looking into this accusation, such as (Willoughby T. et. al. 2011), (Fraser A.M. 2012) and (Espinosa P. and Clemente M. 2013) which show the correlation between video game use and aggressive tendencies.

A study which conducted an online survey involving 790 undergraduate students (547 women and 243 men) and which varied in ethnicity and marital status about various emotional related issues in correlation to gaming. The measurements for the study were violent video gaming, empathic concern and prosocial behavior. The actual online survey required a recruitment code to access it therefore no outside data was being collected, all participants were required to obtain consent otherwise they were unable to start the questionnaire. From this study, they concluded that males play significantly more violent video games than females and due to this females show much higher empathic concern than males and also much higher levels of prosocial behavior towards others. (Fraser A.M. 2012)

Although this study included a larger ratio of women to men, it doesn't have any impact on the results. The study focused on vital topics of research which would ensure results that were useful for example they used the correlation between violent video games and the tendencies of a participant in terms of empathic concern and prosocial behavior. Although an online study, the participants were chosen from a select few universities and were briefed by their lectures on the study beforehand where they were given the recruitment code needed to access the survey therefore overall this study can be applied and counted as reliable.

A study conducted found that boys and girls who regularly played a mature rated video game were more likely to endorse four reasons to play: to compete and win, to relieve anger, modifying games and experimenting with games functionality (e.g. trying out different weapons/vehicles).

No extensive information about the study or the participant's is given, the method of the study is not enclosed so it would be impossible to recreate it in any way so although the conclusions of the study are solid and seem sensible, they can't be relied upon.

Tobias Greitemeyer (2013) conducted research to show that playing video games cooperatively increases empathic concern. Various studies were conducted within this research and various conclusions were reached as a result. Reported empathy differed across certain game conditions, exposure to violent video games resulted in a decreases in empathic concern and playing video games cooperatively resulted in an increase in empathic concern. (Greitemeyer T. 2013)

2.4 Educational Aspects

"Video game play and the potential effects of game play on learning, achievement, and engagement have attracted psychologists, educational researchers, and learning scientists" (Evans M.A. et. al. 2013) Learning and education are the key aspects of life that can define an individual and influence their personalities and alter how they develop. Research conducted by (Evans M.A. et. al. 2013) and (Durkin, K. et. al. 2013) have both looked into the effects video game use can have on education and learning.

Evans M.A. et. al. (2013) used a game known as 'The CandyFactory Game' (CFG) in their research which was designed to accompany middle school students (aged 11–15) algebra readiness and emphasis on fractions. The CFG was created to enable students to physically enact their mental actions in terms of fractions. In the CFG students work their way through five levels that are designed to visually introduce them to the principles of fractions. As they progress, the CFG produces more complex scenarios therefore to complete the game students need to master the five fraction schemes which were: Whole, partitive unit, partitive, Iterative and reversible partitive. Students were accessed at the end of each level and rewarded based on the speed and accuracy they demonstrated.

The five levels enforced the students with different scenarios and ways of thinking. The purpose of the CFG is to measure the effectiveness video games can have on learning and what particular design features can improve an adolescents learning process. They concluded from this study that educational games can be beneficial in a variety of ways (e.g. allowing students to perform actions they are unable to perform in real life, competition, and reward systems).

This experiment focused entirely on the effectiveness of the game itself and little information is given about the group of participant's other than an age range of 11–15 years old. No results of measurements are given other than conclusions that they reached because of the CFG. It is also noteworthy that this is just one game relating to fractions; therefore it is difficult to apply this study to actual video games not fully designed for academic purposes. Evans M.A. et. al. (2013) do not claim to apply their conclusions to video games in general, they place emphasis on the fact that educational games could be beneficial for the learning process of an individual and not video games in general.

3 Discussion & Comparisons

After looking at various research, it is clear that certain theories are backed up by others and some theories don't quite correlate to other findings therefore it is important to compare the implications of these theories.

The first aspect was the cognitive effects of video game use; we found that video game use can have an effect on working memory and attention and that these skills could be enhanced by consistent video game use to then be used in the real world. This would have an impact on the personality development of adolescents as it could potentially increase their general intelligence and problem solving abilities. The next focus was on cheating in video games, although the evidence found was unreliable, it is noteworthy to mention that cheating in video games could have a link to an individual cheating in other contexts which would have an effect on their personality as they would develop a habit of attempting to bypass any effort by cheating at any given task.

The second aspect looked at was the social effects of video game use; we looked at a study that studied the effect video games have on decision making. To put the study into the context of personality development, it shows that playing certain video games can have an effect on how an individual judges certain situations. Although this study was conducted on adults, it can also be applied to adolescents as decision making plays a huge role in growing up and can define the nature of a person. This could mean that consistent video game use could induce tendencies such as tolerance and compassion.

The third aspect looked at was the emotional effects of video game use, we looked at a study that measured the correlation between violent video games, empathic concern and prosocial behavior. This study shows that there is a correlation between certain aggressive tendencies and video game use (Violent video game use in particular) which raises the question; can the personality of an adolescent be influenced by certain video game use? This study shows that playing violent video games can show a reduction in empathic concern and a decrease in prosocial behavior. Adolescents are exposed to many different video games and many of which include violence of some nature. Although the participants of the previously described were between 18 and 29, there is no reason to believe that the effects would be any less significant on an adolescent.

On the other hand video games have often been found to allow individuals to vent their anger without consequence. (Olson C.K. 2010) Video games can allow an adolescent to immerse themselves in unrealistic environment's which in turn can allow them to de stress and vent out their built up aggression where they know they are not going face any repercussions.

The final aspect looked at was education effects of video game use, we found that educational games designed specifically for use in an academic environment could be beneficial but we can't apply this to video games in general. It is difficult to apply the study we looked at to the matter of personality development. Although it would be acceptable to argue that educational games can have an impact on learning and therefore impact an adolescent's personality as a result. This is backed up by research such as (Durkin, K. et. al. 2013) which looks into video games for adolescents with educational needs. Various educational needs are addressed in their research and various uses of video games to help these problems are well demonstrated such as video games to enhance the working memory of adolescent's suffering from ADHD.

4 Conclusions

By looking at the last decade in terms of 'Gaming' there has been a huge incline in its popularity and there is no reason to believe that its popularity won't continue to increase in the next decade therefore video games will continue to be prominent in a large majority of adolescents lives. After pulling together various pieces of research that cover a few positive and negative effects video games can have on personality development, we can conclude that like other media platforms (e.g. Books, Films, TV etc.) video games can have adverse effects on an adolescents personality and how they develop their unique personalities. Also, like other media platforms, it largely depends on what type of games they play. From our research we can conclude that playing violent video games consistently can result in a decrease in empathic concern and prosocial behavior although they allow an individual to vent their built up anger without consequence.

There are many aspects of the effects that video games can have on personality that we have not looked at in this research, we have only covered a very minute section of the potential research that could be conducted but the research covered is important as it exposes the fact that video games do have an effect on personality, positively and negatively.

Finally, we can see from this research that video game use can result in an increase in cognitive abilities, provide social interactions with others, provide emotional help and possibly an increase in academic performance which in turn could result in an adolescent becoming more motivated and intelligent and improve various life skills such as decision making and problem solving. On the other hand consistent video game use in certain types of games can result in emotional strains, less social interactions and poor academic performance which in turn could result in an adolescent becoming more depressed, secluded and distant.

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Appendix 2) Potential Research Subjects and Search Terms

Introduction

Listed on the following pages are some of the topics current researchers are investigating. Under each of these are listed several search terms that can be used to start your literature search.

This list of terms was designed to help you get your literature search started but this is not a comprehensive list of all research topics.

Use a combination of words from the subject headings and the search terms listed underneath to help you find relevant papers e.g. under the subject of astronomy you can combine 'Astronomical Observations' and 'Black Holes'.

Additionally the videos in Chapter 2 will hopefully have inspired you to consider some of the specific subjects mentioned there. If so you can also take key words used by the researchers to help you start your literature search.

Finally you can make up additional terms from subjects you have studied, from chapters of textbooks or from topics mentioned in the news.

2.1 Astronomy Research

Astronomical Observations

- Astronomical Photometry
- Black Holes
- Red Shift
- Spectrum Analysis
- Star Formation
- Stellar Masses

Astrophysics

- Accretion
- Black Holes
- Cosmology
- Gravitational Waves
- Instrumentation and Methods
- Solar and Stellar Astrophysics
- Star Formation

Black Holes

- Active Galactic Nuclei
- Black Hole Physics
- General Relativity
- Gravitational Waves
- Neutron Stars
- Space and Time

Dark Energy/Dark Matter

- Cosmic Background Radiation
- Cosmology
- Interstellar Matter
- Large-scale Structure of Universe
- Supernovae

Galaxies

- Active Galactic Nuclei
- Astronomical Observations
- Black Holes
- Dark Matter
- Galaxies Active
- Galaxies Evolution
- Star Formation
- Supernovae

Stars

- Astronomical Observations
- Binary Stars
- Neutron Stars
- Star Clusters
- Star Formation

2.2 Business Research

Business Administration

- Corporate Culture
- Decision Making
- Economic Development
- Enterprise
- Industrial management
- Management Science
- Marketing
- Organisational Structure
- Personnel Management
- Public Administration
- Risk Management
- Sustainable Development

Business Communication

- Consumer Behaviour
- Decision Making
- Industrial Management
- Information Technology
- Leadership
- Marketing

- Personnel Management
- Social Networks
- Telecommunication
- Wireless Communication Systems

Business Ethics

- Capitalism
- Corporate Culture
- Industrial Management
- Interpersonal Relationships
- Interviewing
- Leadership
- Professional Ethics
- Psychology
- Social Responsibility
- Sustainable Development

Business Intelligence

- Artificial Intelligence
- Data mining
- Decision Making
- Decision Support Systems
- Emotional Intelligence
- Information Technology
- Knowledge Management
- Marketing Strategies
- Strategic Planning

Business Law

- Industrial Relations
- Commercial Law
- Economics
- Industrial Management
- European/International Law
- Corporate Governance
- Contract
- Legislation

Business Management

- Change Management
- Economic Development
- Industrial Management
- Industrial Relation
- Organisational Change
- Risk Management
- Strategic Planning

Business Models

- Data Analysis
- Data Mining
- Decision Making
- Economic Models
- Mathematical Models
- Regression Analysis
- Simulation models
- Statistical Models
- Strategic Models

Business Planning

- Decision Making
- Economic Development
- Economic Policy
- Management Science
- Organisational Change
- Strategic Planning

2.3 Computing Research

Algorithms & Theory

- Algorithm Complexity
- Algorithm Design
- Numerical Analysis

Artificial Intelligence

- Expert System
- Genetic Algorithm
- Machine Learning
- Neural Network
- Vision Recognition

Cloud Computing

- Client/Server computing
- Cloud Security
- Software as a Service (saas)
- Virtualization
- Web Services

Computer Architecture

- Biological Computing
- Cloud Computing
- Operating Systems

Computer Forensics

- Big Data Forensics
- Cloud Forensics
- Computer Forensics Employability
- Computer Forensics Standards
- Digital Evidence

- Digital Investigations
- Evidence Oriented Design
- Forensic Analysis Tools
- Identity Analysis
- Intelligent Analytics
- Intelligent Forensics
- Models for Forensic Processing
- Timeline Analysis

Computer Games Programming

- Artificial Intelligence
- Design
- Educational Games
- Effects
- Game Theory
- Graphics Processing Units
- Graphics Programming
- Machine Learning

- Object Oriented Programming
- Violence
- Virtual Reality

Databases

- Large Databases
- Public Data
- Visual Data

Graphics & Visualization

- Computer Animation
- Interactive Art
- Multimedia
- Rendering

Human Computer Interaction

- Assistive Technology
- Inclusive Design
- Usability

Information Retrieval

- Multimedia Retrieval
- Natural Language
- User Modelling

Information Systems

- Business Needs
- eLearning
- Multiview Method
- Systems Analysis
- User Needs
- Virtual Learning Environments

Internet and Web Technology

- Internet of the Future
- Internet of Things
- Semantic Net
- Web Services

Knowledge Discovery & Data Mining

- Neural Networks
- Semantic Web
- Statistical Approaches

Logic and Semantics

- Formal Methods
- Logic Programming
- Semantic Networks

Media and Communication

- Interactive Television
- Mixed Media
- Protocols

Mobile Computing

- Android
- Devices
- iPhone
- Mobile Technologies
- Wearable computing

Network Systems

- Optical Fibre
- Optimization
- Protocols

Performance Modelling & Analysis

- Metrics
- Optimization
- Testing

Robotics

- Artificial life
- Automation
- Robotic Manufacturing

Software Engineering

- Agile methods
- Context-specific Method
- Formal Methods
- Legacy Methods
- Method Engineering
- Method vs. Methodology
- Object Oriented Design
- Situational Methods
- Web Development Methods

Speech Technology

- Assistive technology
- Hardware for speech technology
- Voice Recognition

Systems Security

- Biometric Systems
- Encryption
- Face Recognition
- Intrusion Detection
- Virus Detection
- Voice Recognition

Wireless Communication Systems

- Bandwidths
- Data Transmission Systems
- Mobile Communication
- Quality of Service
- Receivers
- Signal to Noise Ratio
- Wireless Sensor Networks

2.4 Construction Research

Construction Industry

- Economic Development
- Project Management
- Technology

Energy Consumption

- Conservation
- Efficiency
- Environmental Impact
- Power Resources
- Renewable Energy
- Sustainable Development

Materials Fabrication

- Manufacturing Processes
- Nano Technology
- Polymers
- Semiconductors
- Silicon

Mathematical Models

- Algorithms
- Equations
- Mathematical Optimisation
- Theory

Power Production

- Culture
- Economics
- Electric Power Production
- Globalisation
- Mathematical Models
- Optimisation
- Renewable Energy

Safety

- Industrial Safety
- Nuclear Power Plants
- Public Health
- Risk Assessment
- Work Environment

Simulation Methods

- Computer Simulation
- Electric Generators
- Electric Lines
- Wireless Communication Systems

Urban Planning

- City Planning
- Decision Making
- Economic Development
- Sustainable Development
- Urban Growth

2.5 Engineering Research

Engineering Design

- Communication Systems
- Computer Simulation
- Data Transmission Systems

- Electronics and Electrical Systems
- Energy Consumption
- Information Technology
- Manufacturing Processes
- Mathematical Models
- Optimisation
- Performance Evaluation
- Power Management
- Reliability
- Simulation Methods and Models

Engineering Management

- Decision Making
- Energy Consumption
- Industrial Safety
- Performance Evaluation

Engineering Materials

- Composite Materials
- Fabrication
- Mechanical Properties
- Molecular Structure
- Nano Particles
- Strain
- Strength
- Stress

Engineering Mathematics

- Algorithms
- Control Theory
- Error Analysis
- Genetic Algorithms
- Harmonic Analysis
- Mathematical Models
- Neural Networks
- Signal Processing

Engineering Technology

- Energy
- Integrated Circuits
- Networks
- Simulation Models
- Wireless Communication

2.6 Environmental Research

Biodiversity

- Agriculture
- Climate Change
- Conservation
- Ecosystems
- Forest
- Habitat
- Plant Diversity
- Species Diversity
- Sustainability

Climate Change

- Air Pollution
- Climatology
- Global Warming
- Government Policy
- Precipitation
- Statistics

Ecology

- Biodiversity
- Evolution
- Genetics
- Habitat
- Marine Ecology

Energy Consumption

- Efficiency
- Emissions
- Energy Conservation
- Impact Analysis
- Monitoring
- Renewable Energy Sources
- Sustainability

Environmental Exposure

- Children
- Data Analysis
- Pollution
- Public Health
- Risk Assessment
- Statistics

Environmental Impact

- Children
- Climate Change
- Epidemiology
- Impact Analysis
- Sustainable Development

Environmental Issues

- Children
- Climate Change
- Decision Making
- Deforestation
- Desalination
- Mathematical Models
- Public Health
- Socioeconomic Factors

Environmental Policy

- Climate Change
- Decision Making
- Economic Development
- Environmental Protection
- Finance
- Government Policy
- Public Health

Public Health

- Decision Making
- Environmental Policy
- Epidemiology
- Medical Care
- Physical Activity
- Public Health Interventions
- Public Health Issues
- Public Health Policy
- Socioeconomic Factors

2.7 Humanities Research (Criminology, Culture, Ethics, History, Philosophy and Sociology)

Criminology

- Crime Prevention
- Criminal Behaviour
- Criminal Justice Administration
- Criminal Psychology
- Criminology and Criminal Justice
- Criminology and Public Policy
- Drug Abuse
- Juvenile Delinquency
- Sex Offenders

Culture

- Art
- Children
- Cultural Diversity
- Emigration and Immigration
- Women

Ethics

- Ethical Considerations
- Ethical Decision Making
- Ethical Dilemma
- Ethical Issues
- Human Rights
- Medical Ethics
- Morals
- Professional Ethics

History

- [Insert Name of Country or Region]
- Art
- Legal
- Medical
- Social History
- Technology

Philosophy

- Criticism
- Culture
- Death
- Democracy
- Law
- Music
- Philosophy of Children
- Philosophy of Education
- Science
- Theology
- Theory of Knowledge

Sociology

- Gender
- Globalisation
- Philosophy
- Social Networks
- Sociological Perspectives
- Sociology of Education
- Sociology of Family
- Sociology of Sport
- Woman

2.8 Medical Research

Clinical Trails

- Cognition Disorders
- Cognitive Ability
- Memory
- Neuropsychological Test
- Neuropsychology

Depression

- Cognition
- Depression in Adolescence
- Depression in Children
- Depression in Students
- Depression in Women
- Depression Treatment
- Neuropsychological Test

Epidemiology

- Data Analysis
- Data Analysis Software
- Epidemiological Data
- Epidemiology and Public Health
- Epidemiology of Breast Cancer
- Epidemiology of Depression
- Epidemiology of Eating Disorders
- Epidemiology of Schizophrenia

Genetics

- Epidemiology
- Genetics and Addiction
- Genetics and Intelligence
- Genetics and Obesity
- Genetics and Personality
- Medical Care
- Mental Health

Medical Error

- Disclosure
- In Hospitals
- Management of Medical Errors
- Patient Safety
- Prevention

Medical Ethics

- Care
- Doctor Patient Relationship
- Ethics and Abortion
- Ethics and Decisions Making
- Ethics and Euthanasia
- Ethics and the Law
- Public Health

Medical Technology

- Artificial intelligence in Medicine
- Gene Expression
- Magnetic Resonance Imaging
- Medical Technology Advancements
- Medical Technology Benefits
- Medical Technology Containing Costs
- Robotics in Medicine
- Virtual Reality in Medicine

Medicine Management

- Medicine Management in Nursing
- Medicine Management in the Community
- Mental Health
- Outcome Assessment
- Pain Management
- Public Health
- Treatment Effectiveness

Mental Health

- Aging
- Alzheimer's
- Cognition Disorders
- Depression
- Mental Health Care
- Mental Health Counselling
- Mental health Treatment
- Pathological Psychology
- Psychiatry
- Psychotherapy

- Schizophrenia
- Substance Abuse

2.9 Military Research

Military Children

- Deployment
- Education
- Families
- Post-traumatic Stress Disorder
- Resilience

Military Deployment

- Deployment Policy
- Deployment Strategy
- Impact on Children
- Impact on Families
- International Relationships
- Military Psychology
- Post-traumatic Stress Disorder
- Romantic Relationships
- Stress
- When Parent Returns

Military Families

- Children
- Coping with Stress
- Deployment
- Moving
- Post-traumatic Stress Disorder
- Psychology

Military Sexual Trauma

- Depression
- During Deployment
- Emotional Trauma
- Female Veterans
- Post-traumatic Stress Disorder
- Treatment

Military Spending

- Cuts
- Defence Budget
- Defence Spending
- Economic Growth
- Terrorism

Military Strategy

- Decision Making
- Globalisation
- Historical Perspectives
- Terrorism

Military Technology

- Aeronautics
- Artificial Intelligence
- Communication Systems
- Cyber Technology
- Decision Making
- Drones
- Information Technology
- Missile Defence
- Missile Guidance
- Networks
- Nuclear Weapons
- Remotely Piloted Vehicles
- Robotic Warfare
- Weapons

Military Veterans

- Post-traumatic Stress Disorder
- Transition
- Career Development
- Benefits
- Higher Education

Post-traumatic Stress Disorder

- Mental Health
- Substance Abuse
- Veterans

Terrorism

- Counterterrorism
- Cyberterrorism
- Human Rights
- National Security
- Terrorism Prevention
- Terrorist Attacks

2.10 Psychology Research

Attitude

- Attitude to Health
- Culture

Child Psychology

- Child Abuse
- Child Development
- Child Psychology and Divorce
- Mothers
- Parenting
- Teenagers

Cognition

- Child Development
- Cognition Disorders
- Perception
- Personality
- Visual Perception

Decision Making

- Consumer Behaviour
- Emotions
- Management
- Political

Depression

- Depressive Disorder
- Mental Health
- Pathological
- Psychiatry
- Stress

Emotions

- Emotional Intelligence
- Interpersonal relations
- Social Psychology
- Depression
- Psychoanalysis
- Music

Interpersonal Relations

- Psychotherapy
- Social Interaction
- Social Networks
- Social Perception
- Social Psychology

Learning

- Attention
- Child Development
- Higher Education
- Problem Solving
- Students
- Teaching
- Teaching Methods

Memory

- Language
- Memory and Aging
- Selective Memory
- Short term memory

Mental Health

- Anxiety
- Depression
- Mental Disorders
- Mental Health and Distress
- Mental Health Services
- Psychometrics
- Psychotherapy
- Stress

Motivation

- Leadership
- Motivation in the Workplace
- Motivation and Emotion
- Motivation in Sport
- Motivation of Employees
- Motivational Interviewing
- Motivational Theory
- Student Motivation
- Teaching

Pathological

- Affective Disorders
- Anxiety
- Depression
- Eating Disorders
- Mental Illness
- Neurology
- Personality Disorders
- Psychopathology
- Schizophrenia
- Stress
- Substance Abuse

Psychology and Aging

- Brain
- Cognition
- Dementia
- Medicine
- Memory
- Quality of Life
- Social Support

Psychology Experiments

- on Anxiety
- on Conformity
- on Everyday Life
- on Insomnia
- on Love

- on Music
- on School
- on Sex
- on Sleep

Psychology of Music

- Music and the Classroom

2.11 Robotics Research

Artificial Intelligence

- Autonomous Robots
- Computer Vision
- Genetic Algorithms
- Human-Robotic Interaction
- Image Processing
- Machine Learning
- Neural Networks
- Pattern Recognition
- Robot Motion

Control Systems

- Actuators
- Algorithms
- Artificial Intelligence
- Control Theory
- Detectors
- Kinematics
- Mobile Robots

Human-Robotic Interaction

- Artificial Intelligence
- Human-Computer Interaction
- Humanoid Robots
- Social Interaction
- Virtual Reality

Image Processing

- Cameras
- Computer Vision
- Digital Image Processing
- Feature Extraction
- Image Analysis
- Neural Networks
- Pattern Recognition
- Three Dimensional Imaging

Kinematics

- Biomechanics
- Degrees of Freedom
- Dynamics
- Industrial Robots
- Mobile Robots

Mobile Robots

- Artificial Intelligence
- Autonomous Robots
- Detection
- Navigation
- Path Planning
- Robot Sensing Systems

Neural Networks

- Artificial Intelligence
- Fuzzy Systems
- Genetic Algorithms
- Mobile Robots
- Pattern Recognition

Robotic Engineering

- Actuators
- Control Theory Detectors
- Kinematics
- Manufacturing Processes
- Mobile Robots
- Robotic Control Systems

Robotic Surgery

- Complications
- Costs
- Endoscopic Surgery
- Ethics
- Failures
- Laparoscopy
- Prostatectomy

Robotic Warfare

- Drone Aircraft
- Ethics
- Military Robots
- Remotely Piloted Vehicles

Robotics in Manufacturing

- Automobile Industry
- Industrial Productivity
- Space Vehicles

Robotics in Medicine

- Imaging Systems in Medicine
- Magnetic Resonance Imaging
- Medical Care
- Rehabilitation
- also see Robotic Surgery

2.12 Science Research (Biology, Chemistry, Mathematics and Physics)

2.12.1 Biology Research

Apoptosis

- Antineoplastic Agents
- Cancer Cells
- Cell Proliferation
- Gene Expression
- Mitochondria
- Oxidative Stress

Biodiversity

- Biogeography
- Biotic Communities
- Climatic Changes
- Conservation
- Habitat Ecology
- Species Diversity
- Taxonomy

Cell Proliferation

- Apoptosis
- Cell differentiation
- Cellular Signal Transduction
- Gene Expression
- Stem Cells

DNA

- DNA Damage
- Gene Expression
- Genetic Regulation
- Genetics
- Genomics
- Mitochondrial DNA
- Phylogeny
- Polymerase Chain Reaction

Evolution

- Biodiversity
- Climatic Changes
- Gene Expression
- Genomics
- Mutation
- Nucleotide Sequence
- Phenotype
- Phylogeny

Gene Expression

- Apoptosis
- Arabidopsis
- Cancer Cells
- Cellular Signal Transduction
- Genetic Regulation
- Messenger RNA
- Transcription Factors

Genetics

- Cellular Signal Transduction
- Gene Expression
- Genetic Polymorphisms
- Genetic Regulation
- Nucleotide Sequence

Genomics

- Computational Biology
- Gene Expression
- Genetic Polymorphisms
- Genetic Regulation
- Nucleotide Sequence

Molecular Biology

- Apoptosis
- Cellular Signal Transduction
- Gene Expression
- Mutation
- Proteins

Mutation

- Gene Expression
- Genetic Polymorphisms
- Genetics
- Nucleotide Sequence
- Phenotype
- Proteins

Neurons

- Alzheimer's
- Brain
- Cellular Signal Transduction
- Gene Expression
- Mutation
- Neural Circuitry
- Neurodegeneration
- Neuroscience

Phenotype

- Cellular Signal Transduction
- Gene Expression
- Genetic Polymorphisms
- Genetics
- Mutation
- Transcription Factors

2.12.2 Chemistry Research

Nanoparticles

- Nanocomposite Materials
- Nanostructured Materials
- Transmission Electron Microscopy
- X-Ray Diffraction

Organic Synthesis

- Crystal Structure
- Hydrogen Bonding
- Molecular Structure
- Nanoparticles
- Ring Formation

Physical Chemistry

- Chemical Reactions
- Nanoparticles
- Temperature Effect
- Thermodynamics
- X-Ray Diffraction

Polymers

- Fourier Transform Infrared Spectroscopy
- Nanocomposite Materials
- Nanoparticles
- Polymerisation
- X-Ray Diffraction

Proteins

- Amino Acids
- Biochemistry
- Gene Expression
- Oxidative Stress
- Peptides

Surface Bonding

- Adsorption
- Chemical Bonds
- Density Functionals
- Hydrogen Bonding
- Nanoparticles

Theoretical Chemistry

- Density Functional Theory
- Density Functionals
- Molecular Dynamics
- Molecular Structure
- Quantum Chemistry

2.12.3 Mathematics Research

Control Theory

- Approximation Theory
- Mathematical Models
- Mathematical Optimisation
- Robust Control
- Simulation Methods and Models

Error Analysis

- Approximation Theory
- Estimation Theory
- Mathematical Models
- Numerical Analysis
- Regression Analysis

Mathematical Analysis

- Algorithms
- Approximation Theory
- Mathematical Models
- Mathematical Physics
- Mathematical Proofs
- Numerical Analysis
- Set Theory
- Stochastic Convergence

Mathematical Models

- Approximation Theory
- Computer Simulation
- Mathematical Analysis
- Mathematical Optimisation
- Mathematical Physics
- Numerical Analysis
- Parameter Estimation
- Probability Theory

Mathematical Optimization

- Algorithms
- Approximation Theory
- Genetic Algorithms
- Mathematical Programming
- Numerical Analysis
- Simulation Methods and Models
- Stochastic Convergence

Mathematical Statistics

- Correlation
- Data Analysis
- Descriptive Statistics
- Estimation Theory
- Mathematical Analysis
- Mathematical Models
- Regression Analysis

Probability Theory

- Distribution
- Estimation Theory
- Markov Processes
- Mathematical Models
- Random Variables
- Random Walks
- Stochastic Processes

Set Theory

- Algorithms
- Approximation Theory
- Graph Theory
- Group Theory
- Mathematical analysis
- Mathematical Models
- Matrices
- Perturbation
- Probability Theory

Stochastic Convergence

- Approximation Theory
- Convergence
- Iterative Methods
- Mathematical Optimisation
- Numerical Analysis
- Stochastic Processes

2.12.4 Physics Research

Fluid Dynamics

- Computational Fluid Dynamics
- Heat Transfer
- Hydrodynamics
- Molecular Dynamics
- Numerical Analysis
- Simulation Methods and Models
- Turbulence
- Viscosity

Magnetic Fields

- Anisotropy
- Electric Fields
- Magnetic Properties
- Magnetisation
- Phase Transformations
- Plasma

Nanoparticles

- Nanocomposite Materials
- Nanostructured Materials
- Nanostructures
- Transmission Electron Microscopy
- X-Ray Diffraction

Nuclear Physics

- Collisions
- High Energy Physics
- Magnetic Fields
- Monte Carlo Method
- Nuclear Theory
- Particles
- Quantum Theory
- Scattering

Quantum Theory

- Density Functionals
- High Energy Physics
- Perturbation
- Photons
- Quantum Dynamics
- Quantum Entanglement
- Quantum Field Theory

Spectrum Analysis

- Mass Spectrometry
- Molecular Structure
- Raman Spectroscopy
- X-Ray Diffraction

Thermodynamics

- Entropy
- Free Energy
- Heat Transfer
- Molecular Dynamics
- Phase Transformations
- Temperature Effect
- Thermodynamic Equilibrium

2.13 Space, Aircraft and Automotive Research

2.13.1 Aircraft Research

Aeronautics Safety Measures

- Accident Prevention
- Air Traffic Control
- Airworthiness
- Flight Training
- Global Positioning System
- Risk Assessment

Aircraft Accidents

- Accident Investigation
- Accident Victims
- Air Pilots
- Flight Training
- Safety Measures
- Terrorism

Aircraft Design

- Aerodynamics
- Aeronautics
- Aircraft Components
- Composite Materials
- Computer Software
- Remotely Piloted Vehicles

Aircraft Engines

- Aerospace Technology
- Engine Design
- Jet Engines

Aircraft Manufacturing

- Composite Materials
- Drone Aircraft
- Helicopters
- Military Airplanes
- Parts Manufacturing

Remotely Piloted Vehicles

- Autonomous Vehicles
- Flight Testing
- Military Vehicles
- Remote Control
- Remote Sensing

2.13.2 Automotive Research

Automotive Engineering

- Composite Materials
- Corrosion
- Energy Consumption
- Financial Performance
- Lightweight Engineering

Automotive Fuel

- Alternative Energy
- Electric
- Emissions
- Energy
- Fuel Cell
- Hybrid Electric

Automotive Mechanics

- Composite Materials
- Computer Simulation
- Deformations
- Fracture Mechanics
- Mathematical Models
- Strains and Stresses
- Strength of Materials
- Vibration Mechanics

Electric Vehicles

- Battery
- Charging station
- Electric Grid Demand
- Energy Consumption
- Environment
- Fuel Cells
- Hybrid Electric
- Lithium Ion batteries

Self Driving Cars

- Autonomous Cars
- Driverless Cars
- Efficiency
- Liability Law
- Safety
- Traffic Accidents
- Traffic Safety

Traffic Accidents

- Accident Prevention
- Causes
- Driving
- Fatalities
- Injuries
- Quality of Life
- Teen Drinking
- Traffic Safety
- Trauma

Traffic Congestion

- Air Pollution
- Causes
- Economic Development
- Freight
- Infrastructure
- Railroads
- Shipping
- Simulation Models
- Solutions
- Traffic Engineering
- Traffic Flow
- Urban Planning
- Water Transportation

2.13.3 Space Research

Space Colonisation

- Biodiversity
- Biotic Communities
- Ecology
- Habitat

Space Exploration

- Communication
- Costs
- Funding
- Mathematical Models
- Outer Space
- Problems
- Pros and Cons
- Psychology
- Technology

Space Travel

- Costs
- Mars
- Propulsion Systems
- Psychological Effects
- Space Time
- Technology

2.14 Sports Research

Athletes

- Anthropometry
- Biomechanics
- Coaches
- Olympics
- Parasport
- Professional Athletes

Automobile Racing

- Drivers
- Engineering
- Engines
- Racetracks
- Rallies

Baseball

- Exercise Physiology
- Injuries

Cycling

- Aerobic Exercise
- Exercise Physiology
- Heart Beat
- Muscle Strength
- Oxygen Consumption

Exercise

- Aerobic Exercises
- Aging
- Body Mass Index
- Body Weight
- Exercise Intensity
- Fatigue
- Muscle Strength
- Obesity
- Physical Education
- Quality of Life

Football

- Anthropometry
- Exercise Physiology
- Injuries
- Muscle Strength
- Performance

Golf

- Golf Balls
- Golf Swing
- Instruction
- Techniques

Muscle Strength

- Anatomy Joints
- Biomechanics
- Exercise
- Exercise Physiology
- Muscle Contraction

Physical Education

- Body Mass Index
- Children
- Exercise
- Fitness
- Health Behaviour
- Obesity

Physical Fitness

- Body Mass Index
- Children
- Exercise
- Exercise Physiology
- Health Behaviour
- Muscle Strength

Running

- Anthropometry
- Biomechanics
- Exercise Physiology
- Exercise Tests
- Heart Beat
- Muscle Strength

Sport Injuries

- Anatomy Joints
- Anterior Cruciate Ligament
- Arthroscopy
- Biomechanics
- Children
- Epidemiology
- Magnetic Resonance Imaging
- Psychological Factors
- Rehabilitation
- Sports Medicine
- Treatment Effectiveness

Sport Management

- Health Behaviour
- Health Promotion
- Public Health
- Rehabilitation

Sport Marketing

- Advertising
- Careers
- Consumer Behaviour
- New Demographics
- Promotions
- Strategy
- To Children

Sport Medicine

- Biomechanics
- Ethics
- Exercise Physiology
- Physician

Sport Nutrition

- Body Weight
- Diet
- Health Behaviour
- Market
- Nutrition Needs
- Supplements

Sport Performance

- Anxiety
- Drugs
- Enhancement
- Home Advantage
- Nutrition
- Testing
- Training

Sports Psychology

- And Performance
- Anxiety
- Children
- Goal Setting
- Health Behaviour
- Motivation
- Stress

Swimming

- Anthropometry
- Athletes
- Body Mass Index
- Exercise Physiology
- Health Behaviour
- Swimmers

2.15 Technology Research

And Children

- Child Safety
- Location Tracking
- Parental Decisions
- Use of Technology

And Education

- Benefits
- Computer Assisted Instruction
- Critical Thinking
- Education Technology
- Internet in Education
- Student Learning
- Teaching Methods

Games

- Computer Programming
- Game Theory
- Video Games
- Virtual Reality

In the Classroom

- Classroom Environment
- Computer Assisted Instruction
- Distance Education
- Education Technology
- Increase Learning
- Internet
- Student Achievement
- Teaching Methods

Information Technology

- Decision Making
- Information and Communication Technologies
- Information theory
- Problem Solving

Internet

- Addiction
- Blogs
- Internet in Education
- Internet of Things
- Internet Users
- Online Social Networks
- Privacy
- Web-based Instruction

Technological Innovations

- Decision Making
- Economic Development
- Educational Technology
- Innovations in Business
- Reproductive Technology
- Strategic Planning