

Writing a research paper

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Summary The aim of this article is to help those embarking on research to communicate effectively through writing, and to improve their chances of getting a paper published. The quality of a paper's *research content* is judged by originality, importance and scientific validity. Advice should be sought on a project's potential for high-quality research content before taking up the research. When readers have difficulties in understanding a paper, the problem more often lies with *presentation and structure* than with its scientific content. Readers expect information to be presented in a certain way and when this does not happen they may misinterpret what the writer intended.

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PRACTICE POINTS

Preparing the first draft

- agree early on who are the contributors to the paper
- choose a lead writer
- choose a working title before commencing the first draft
- follow precisely the journal's 'instructions for authors'
- aim to complete the first draft in one sitting

Getting the message across

- emphasize information by placing it at the end of the sentence or clause
- do not provide lengthy information between subject and verb
- provide the reader with *context* and *perspective* by appropriate use of topic positions
- move the reader on by verbs that have a sense of action

INTRODUCTION

Science cannot advance unless research findings are effectively and widely *communicated*. The purpose of this article is to help those embarking on research to communicate effectively through writing, and to improve their chances of getting a paper published.

Decide early on who are the contributors to the proposed paper as this may avoid conflict later. Although not every contributor need play a part in the writing, each is nonetheless accountable for the paper and must be able to justify the part they played in the research. Some journals request this information when the paper is submitted.

Select a lead writer who will be responsible for drafting most of the paper and for circulating it to the other contributors for their comments. Certain sections may have to be written by contributors with special knowledge, but the lead writer must retain overall control, collate suggestions and produce further drafts until all contributors are happy with the final product.

Try to complete as much of the first draft as you can in one sitting. Have with you a few copies of the journal you are submitting to, ensure you follow the instructions to authors, and that tables and figures are styled appropriately. Begin by choosing a working title for the paper, and keep it as short and as simple as possible. Expressing a statement in the title is risky especially in clinical research. Although '*Rotavirus causes necrotizing enterocolitis*' looks compelling, if the referee criticizes the scientific validity the paper is damned through its title. Yet it may contain publishable research findings if interpreted differently. When the final draft of the paper has been completed, always reconsider the title and its appropriateness.

The important qualities of a scientific paper are its *research content* and its *presentation and structure* and these are the themes of this article.

RESEARCH CONTENT

The research content of a scientific paper is all the material of the research. It includes what you did; why you did it, how you did it, your results and their interpretation; and what you concluded. The *quality* of the research content is the most important factor influencing whether a paper is accepted or rejected and is assessed on the basis of originality, importance and scientific validity.

Before undertaking a project, experienced researchers always assess its potential for high-quality research content. This assessment is crucial for doctors taking time out to undertake a project. Otherwise a year or more of work may culminate in discovering the research findings are unoriginal, unimportant or scientifically flawed.

Originality

Originality in this context means whether the research adds to knowledge in a material way; does it move the subject matter further forward? Research that confirms the findings of others may still be original. For example, the findings of some published research arise *outside* a tested hypothesis. Here, there is scope for other researchers to pose a hypothesis specifically to test the original results. Differences in laboratory methods may also be relevant in confirming the findings of others while retaining originality. In short, the same results may stem from different research pathways—and this may be important in conferring originality.

Importance

The notion of importance is relative and to some degree subjective. In basic science, most original discoveries are important because they expand the knowledge base regardless of their implications, which at first may be unclear. In clinical research, the *implication* of an original finding has a crucial role in defining importance. A study on the prevalence of Asperger syndrome in Manchester is original if no one else has done it. However, data may exist for Leeds, Birmingham and many other cities. Originality simply through geography is not important *unless* the investigators have specifically tested a hypothesis that some social or biological reason explains why the prevalence in Manchester may be different.

Scientific validity

When a paper is criticized on the basis of scientific validity, the problem usually lies with the methods or with the analysis of the results. While there may be an opportunity to reanalyse the results, perhaps using more appropriate statistical tests, the methods cannot be changed without re-doing the research—what is done is done.

That is why it is so important for those embarking on a project to seek advice beforehand.

PRESENTATION AND STRUCTURE

The purpose of writing is to communicate precisely to readers. A paper's presentation and structure determine whether it will be understood in the way that was intended; so the writer needs to understand how readers expect information to be presented. First, I will discuss the presentation of the main sections of the paper; then I will explain how writers can get their information across with the meaning they intended—writing with structure.

Most scientific papers are presented in sections: introduction, methods, results and discussion. The reader expects the material in each section to serve a distinct purpose. Information from one section is retained as the next section is read, and so the reader also expects a logical and understandable link between the sections.

Introduction

The purpose of the introduction is to help readers understand what the paper is about [context], and where it is going [perspective]. An introduction that is brief, coherent, logical and stimulating puts the reader in a receptive mood.

The aims of the study need to be stated with clarity. One reason for this is that a test of a paper's scientific validity is whether appropriate methodology was used to answer the research questions posed. If referees cannot identify the research questions, the paper has got off to a very bad start. For some papers, the research questions need to be posed as one or more hypotheses. It is helpful to start by drafting the *end* of the introduction, explaining the aims and hypotheses here, where they are more likely to be retained as the reader progresses to the method section. You are then in a better position to decide what material is needed in the main body of the introduction to provide *context* for your research questions. This lessens the chance of finishing up with a long-winded, rambling introduction with irrelevant information.

Methods

You may have been doing the research for a year or more, but in the space of a few minutes the reader has to learn what you have done. Explaining what you did is the active part of the paper and readers have a sense of involvement with this section. They imagine they are doing what you have described, and so it is important to present information in a *logical order*. Usually, this means a chronological order. If many different

procedures were used and the chronology is not crucial, then provide order for the reader by explaining each procedure under a separate sub-heading.

Clarity and precision are essential. Use a flow diagram when describing a complex methodology where there are many procedural steps. Descriptions of a study population that have required many exclusions, each for a different reason, can also be difficult to assimilate without a flow diagram.

The statistics used to analyse the results should be stated informatively — not simply by a list of named tests. Show instead how the choice of each statistical test depended on the nature of the data. If a computer statistics program has been used, then give its name but the statistical tests used must still be shown, rather than simply: 'We analysed the results using Easistat [Alrincham, UK].'

The ethics of research will continue to have a high profile. Indicate whether the research was considered and approved by a recognized ethics committee. Where a consent procedure was needed show who sought consent, and in more general terms when it was sought and obtained.

Results

Readers expect to see how the results accord with the aims of the study, and any hypotheses that were posed. They should not have to wade through masses of disorderly information to get to this information, and so the way the results are presented needs to be planned thoughtfully. This is not easy when the research has generated numerous results.

One procedure is to write on the top of a sheet of paper the aims of the study and the hypotheses to be tested. Underneath, write *all* the results, including comparisons you have made between groups, and other analyses. Cluster the results so that they form natural groupings, each with a subheading, e.g. demographic data, serum sodium data, etc. At this stage, you may find certain results belong to more than one group.

Refer to the top of the page, and answer the aims of the study and any hypothesis by ordering the clusters in a logical way. Delete from each cluster any result that does not contribute *in any way* to answering aims or testing the hypothesis but remember that certain negative results may still be relevant. If you come across a chance observation, outside the aims of the study, that you feel is *important* [not simply interesting] then include it. Using this approach you are more likely to produce a concise and logically ordered results section that answers the aims of the study without burdening the readers with extraneous material that distracts from the key findings.

Use tables and figures thoughtfully with the reader in mind. For example, if you need to show trends with time then a figure is obviously helpful; but there is no point in including a histogram that simply compares the mean

[SD] values of two groups when two lines of text suffice. Authors are often uneasy about the request not to duplicate in the text material that has appeared in tables or figures. There is no harm in emphasizing one or two key results that have been tabulated but the onus is on the writer to ensure that *whatever form* a key result is presented its *presentational qualities* attract the reader's attention.

Discussion

A summary of the main research findings should appear early in the discussion. The main purpose of the discussion is to *interpret* the results in a way that allows readers to know whether you have reliably fulfilled the aims of the study and answered the research questions posed.¹ The extent to which your results are supported by other researchers should be indicated, and where differences exist you should try and explain why. The strengths and weaknesses of the study should be alluded to. Instead of putting forward an excuse [e.g. *time constraints did not allow us to study more patients*] try and clarify the effect of any weaknesses. For example, you may need to explain why a particular result or group of results was probably not influenced by a certain methodological constraint.

Research findings mean little without knowledge of their *implications* and importance. These should appear towards the end of the discussion but avoid travelling down a tortuous explanatory path simply to attach importance to your findings. Often the value of the research amounts to 'another piece in the jigsaw' and is dependent on further research to move the subject on towards greater implication. This needs to be stated within the context of your study. It provides an opportunity to end the discussion with pointers towards the kind of research that would be helpful. However, simply ending a paper with an isolated statement without context: 'We conclude that further research is needed' is a journalistic hanging offence. Of course, further research is needed—we rarely read: 'We conclude that our findings are the final say in this matter. No further research is needed.'

The abstract

The abstract is the shop window of the paper. It is reproduced electronically and appears in research databases making it widely accessible. It is likely to be the only part of the paper that is read by a majority of readers—they want to know the overall thrust of the paper and its message. The abstract should be structured in content even if the journal does not ask for structured subheadings such as aims, methods, results, conclusions.

The word limitation must be adhered to and it needs discipline to select only the information that is vital to an understanding of the paper. The following sequence may

help. First, decide what are the key messages of the paper—these come in the conclusion of the abstract. Then, restrict the results to those that *explain* the messages, and include sufficient methodology to enable the reader to know *how* those results were obtained. Finally, decide what information is strictly needed to put the results and the derived messages into context—this will be the opening lines of the abstract.

WRITING WITH STRUCTURE

When readers have difficulties in understanding a paper, the problem more often lies with the way the text is *structured* than with its scientific content. Nicely structured papers are often found in journals of physics and mathematics. We may not understand the science but we come away knowing *what it is* that we do not understand. Readers expect information to be presented in a certain way. When this does not happen they are confused because the paper is impenetrable. They may wrongly attribute their confusion to a lack of understanding of the science; worse still they may misinterpret the information.

Readers want to be moved through each piece of information by a series of actions found in the verbs. They expect sequences of tension followed by resolution as they absorb the paper's factual information. As each new piece of information is presented they need to know who the player is, how it is linked with information in the preceding text, and to feel that it provides perspective for the next piece of text. They need to be able to determine important information quickly and distinguish it from the less important.

Writing with structure is not the same as getting the grammar right, although grammatical construction does play a part in getting the message across in the way the writer intended. In the following account, I have relied heavily on the work of Gopen and Swan which is essential reading.²

The stress position

A single sentence often contains several pieces of information. The information you wish to emphasize should occupy the end of the sentence or clause. Gopen and Swan² refer to this as the stress position and it corresponds to the moment of syntactic closure. Stress positions can be occupied by one word, several words or even a lengthy phrase. What matters is that once syntactic closure is reached readers know they have reached the end of that piece of information and they can look forward to something else.

Consider the following text:

The same population was later used to refine the haplotype association using additional probes to ascertain the

strongest association within the region, leading to the conclusion that the gene contributing to susceptibility was centromeric to V beta II, not within the constant, diversity or joining segments, but probably within the variable region itself.

There are many pieces of information jostling with each other, and the reader needs clues to assess their relative importance. I have created stress positions to highlight one interpretation of this information.

We refined the haplotype association in the same population. The strongest association within the region was ascertained using additional probes. We concluded that the gene contributing to susceptibility was not within the constant, diversity or joining segments. It was centromeric to V beta II and probably within the variable region itself.

We now attach importance to the fact that the same population was used, and that additional probes were used; that the gene was not within the constant, diversity or joining segments, and that it was probably within the variable region. Here is another version with different information in accentuated or stress positions:

Using additional probes in the same population we refined the haplotype association to ascertain the strongest association within the region. We concluded that the gene contributing to susceptibility was centromeric to V beta II. It was not within the constant, diversity or joining segments but was probably within the variable region.

The important information here is rather different: the strongest association within the region was ascertained; the gene was centromeric to V beta II, and it was probably within the variable region. Only the author knows how the text was meant to be interpreted.

Subject–verb separation: getting to the action

When the subject or topic of a sentence is introduced it creates tension; the reader expects the verb [the action] to arrive quickly and the tension resolved through syntactic closure. Lengthy text between the subject and the verb may contain information that the author wants to get across. Yet the reader, searching for the action, may not attach much importance to this intervening text. Consider for example,

Fetal asphyxia, a combination of acidemia, hypercapnoea and hypoxaemia, occurring before labour during labour, or during delivery itself, especially if complicated, contributes to a significant proportion of brain damage in infants who are born at term.

The text separating the subject [fetal asphyxia] from the verb [contributes to] contains information that may be important. Also, when syntactic closure occurs it is a

disappointment because the expression 'contributes to a significant proportion of brain damage in infants who are born at term' is weak and hardly worth the time it took to get there. There is not much action in it. The following may be a better interpretation of what the author wanted to get across:

Fetal asphyxia may be defined as a combination of acidemia, hypercapnoea and hypoxaemia. It can occur before labour, during labour, or during a complicated delivery. It is responsible for a significant proportion of brain damage in term infants.

The topic position

The subject matter [what the story is about] placed at the beginning of the sentence in what is known as the topic position gives the reader a sense of direction or perspective. In this position, it also serves as a link backwards to the preceding text to provide context. Readers expect both perspective and context; without them they lose the thread of the text and may not understand it, or may misinterpret what the writer intended. Consider the following:

There is an association between raised levels of inflammatory mediators in amniotic fluid and periventricular echodensities observed on ultrasound scans. Experimental models of birth asphyxia in preterm animals have shown that damaged areas of the brain contain raised levels of inflammatory mediators. Although cerebral palsy may evolve in some preterm infants with periventricular echodensities the relationship between inflammatory mediators and cerebral palsy merits further study.

It is difficult to pick up the thread of this story because the key player is difficult to identify. Also, there is little in the way of context because topic positions do not comfortably link with preceding text. The following rearrangement is not perfect but the context and perspective are improved:

There is an association between raised levels of inflammatory mediators in amniotic fluid and periventricular echodensities in preterm infants. These lesions observed on ultrasound brain scans may be markers for the development of cerebral

palsy. The relationship between cerebral palsy and perinatal inflammatory mediators merits further study. This is especially relevant because raised levels of inflammatory mediators have been observed in areas of damaged brain in animal models of experimentally induced birth asphyxia.

When we attach importance to the arrangement of topic positions, it can sometimes reveal gaps in the context of our text where additional information needs to be included to strengthen the thread of the text.

The key message factor

A useful test of the presentation and structure is whether there are clearly discernible key messages. It is good discipline to prepare a key message box even if the journal does not request it. When a writer critically analyses the text in relation to the key messages, deficiencies in presentation and structure may come to light.

CONCLUSIONS

Writing with the reader in mind takes on a special meaning when we consider that the referee is usually the first external reader to study your paper critically. There may be little that can be done to retrieve a paper that is flawed on the basis of its research content—the problems should have come to light before starting the research. It is frustrating however when quality research content is misunderstood or is impenetrable to the referee. This is not usually the referee's fault—but the writer's.

REFERENCES

1. Skelton J R, Edwards S J L. The function of the discussion section in academic medical writing. *Br Med J* 2000; 320: 1269–1270.
2. Gopen G D, Swan J A. The science of scientific writing. *Am Scientist* 1990; 78: 550–558.

FURTHER READING

Markman P T, Markman R H, Waddell M L. *Ten Steps in Writing the Research Paper*, 6th edn. Barron's Educational Series, 2001.