

Honest Research

Harold Hillman

Unity Laboratory of Applied Neurobiology, University of Surrey, UK

Abstract: *The origins of research projects, the duties of supervisors and research workers, the subjective elements in research and the difficulties of publication are reviewed, as a guide to the complexities of executing an honest research project. It is assumed that research carried out with maximal intellectual integrity will result in real advances.*

Keywords: scientific integrity; research supervision

THE AIM OF RESEARCH

One may regard it as axiomatic, if naive, that the most important intention of research is the discovery of *truth*. This has been defined elsewhere in respect of biology as the most accurate description of the state in living humans, animals, plants and microorganisms which we may approach that respects the natural laws currently believed and is consistent with the maximum tested experimental evidence from living organisms¹. It is reasonable to assume that truth is sought, because truthful descriptions facilitate accurate policies, the production of greater wealth, the creation of a just society and the aggrandizement of people. There also seems to be a very deep human instinct to seek out the truth, whose origin is difficult to know. Of course, these are only my assumptions although I believe that they are widely shared. Academics have an extra responsibility because they are believed to be objective seekers after truth, not influenced by commercial motivation, self interest or ambition. In other words, they and the public both believe that academics have intellectual integrity and steps should be undertaken to ensure that this belief is correct.

THE ORIGIN OF A RESEARCH PROJECT

The idea for a project may come from:

- a. a question raised by a finding or an apparent anomaly, arising out of a research programme;
 - b. repetition of previous experiments or observations to test their veracity;
 - c. an original approach after consideration of the literature or a novel insight;
 - d. a request from industry or commerce to solve a particular problem. In
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Address for corresponding author: Dr. H Hillman, Director, Unity Laboratory of Applied Neurobiology, University of Surrey, Guildford, Surrey, GU2 5XH, UK. (Paper received 25 March 1994, revised 26 May 1994, accepted 10 June 1994.)

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academic research, many projects originate from the interests of the supervisor. There is a frequent tendency for junior lecturers to set up research projects in the areas about which they know most, that is, the subjects of their own doctorates.

The supervisors - both in academia and industry - should know the literature, have experience of the techniques involved, recognise the necessity to improve current techniques and develop new ones, and be acquainted with the work of national and international experts on the subject. They should not supervise projects outside their own fields. It should always be borne in mind that most obvious projects - but not all - have previously been thought of by those well acquainted with the field. A project does not have to be original to be of value but the research worker who knows about previous endeavours along the same line has a considerable advantage.

THE DUTIES OF THE SUPERVISOR

These may be summarized:

- i. to propose a project which the research worker has the training and knowledge to carry out in the time available;
- ii. to give the research worker key references to the literature so that the worker can understand the rationale, techniques, results and consequences of the various possible outcomes of the project;
- iii. to explain the intellectual basis of the project, the assumptions necessarily inherent in it, how they may be tested, the techniques to be used (including their ranges, errors, calibrations) and the literature of those disagreeing with the supervisor's views;
- iv. to meet the research worker regularly to discuss the project, to see the raw data and to discuss any intellectual difficulties which arise. It is of the utmost importance to examine the raw data; together, they can check that there are no systematic errors, mistakes in calculations, inappropriate blanks, contamination, non-linear effects, etc. In any laboratory or digital investigation, one occasionally finds a few values which are quite outside the range of all others. All those involved in the project should decide *beforehand* whether and by what criteria any values will be discarded; these criteria should be written down. One should not abandon any values which do not meet these criteria;
- v. the supervisor of laboratory-based and survey data is responsible for seeing that all raw data is preserved for future scrutiny by interested parties, for example at the examination of a thesis or following allegations of fraud;
- vi. the supervisor should be prepared to discuss any aspect of the project including 'awkward' questions at any time, to examine literature to which the research worker draws attention and to change his or her mind about any aspect of the project;
- vii. the supervisors usually write or oversee the writing of the results of the projects for publication. They, therefore, share the achievement and the glory of important discoveries. By the same token, they share the responsibilities for any interpretations, mistakes, fraud, wrong conclusions or errors. In many recent cases of fraud, particularly in the United States, co-authors have

- written to journals abjuring their authorship - without admitting their common responsibility for the publication, apologizing to their colleagues or accepting the obloquy of the misdemeanours²⁻⁴;
- viii. the supervisors also have the responsibility to inform research workers, especially training for a higher degree, about meetings relevant to the project, about interesting lectures and to introduce them to other experts in the subject;
 - ix. there is a continuous responsibility to encourage intellectual honesty, including open discussion, and to explore differences of scientific opinion about important topics;
 - x. in my opinion, the supervisor of a doctorate has a duty to help the former student to find a job after completing the thesis, although this may be regarded as a moral rather than a professional responsibility.

This burdensome list is designed to show supervisors what responsibilities they are taking on when they agree to supervise research work.

HOW THE RESEARCH WORKER SHOULD PROCEED

The research workers should be acquainted with the basic subject which they are to investigate. If not, they should devote a considerable time to reading the classical textbooks and acquiring the vocabulary and concepts of the subject. This may require attendance at classes in the discipline which are compulsory in the United States but not in Britain. Since photocopiers have become popular, research workers have acquired the habit of copying a large number of publications with a view to reading them subsequently. Often, they are not read at all. A much better practice is to read a paper, to decide if it is relevant, record its full reference on an index card and then write down a summary in one's own words of what it contains. Merely reading it or copying out the abstract is not enough; it can be done while watching a football match on television, that is, without *cerebration*. Of course, the more one thinks about a publication, the more useful it becomes intellectually.

The supervisor should give the research worker *key* references in an area in which the former is an expert. The research worker examines these in detail and looks up the earlier key references quoted there. It is a common practice - which is to be deplored - for the research worker to be sent early on to the library to do a literature search. Unfortunately, sometimes the supervisor does not know the literature in the project being supervised but an early literature search is nearly always a waste of time. The data base is likely to produce a long roll of papers, many in foreign languages, of poor quality or containing unsupported opinions rather than new data. Librarians are aware of the widespread abuse of their information services. *After* one has read and annotated a significant number of papers, then it is wise to photocopy only those containing much data or seminal concepts, for subsequent reference. The assessment of the validity of a published paper will be discussed below.

When research workers feel that they have a grasp of a problem, they should then write a review for themselves and their supervisors on its status in relation to their projects from their reading of the literature. This should concentrate on identifying the landmarks in the development of the subject, the validity of the

techniques being used, the assumptions inherent in the project and its possible applications in the future. Sometimes, at this stage, the research workers may conclude that the projects are not worth pursuing. However, most of them see their supervisors as intellectual superiors who have obtained funds and, therefore, must be very clever. They are reluctant to ask fundamental questions nor insist on answers. They often do not understand the difference between findings and hypotheses and do not feel confident enough to ask their supervisors which of the statements are based on published findings and which are hypotheses of their supervisors or predecessors.

Thus, the interpretations, theories and hypotheses of one generation are gradually apotheosed to findings in the next generation. Elsewhere, I have listed well-known hypotheses in biology which are so widely assumed that even experienced and professional biologists regard them as findings ⁵ (pps. 242-243). Indeed, I would suggest that the failure to distinguish between the two is the biggest single misdemeanour of the modern thinker, scientist and politician. Many do not accept a real distinction. Others do not agree with Popper that a useful hypothesis *must* be posed in a disprovable form, if it is to be valuable ⁶

HOW TO ASSESS THE VALUE OF A PUBLICATION

One may use the same procedure to write one's own paper as one does to assess published works. This is best done by asking the following questions:

- i. what are the basic assumptions behind the paper? This question is *rarely* asked and even more rarely answered by authors. They often fail to identify any of them; while it is obvious that this is the most important question whose answer decides the fundamental truth of the result of any investigation⁷;
- ii. how specific is the procedure used for answering the question posed?
- iii. what control experiments have been done to establish that the effects or differences detected are not the results of the observational or experimental procedure used but reflect real differences between the two populations?
- iv. have the authors used appropriate statistical methods ^{8,9}? Have the statistics been correctly used?
- v. what criticisms would a *hostile* referee pose and have they been met?

It is the duty of an academic or author of a learned publication to answer polite or serious questions from any interested party ¹⁰; it would be quite proper for a research worker or student to write to the authors of any publication to ask any of the above questions. My experience is that such letters are usually either not answered at all or are answered sufficiently briefly to avoid detailed consideration of the questions and further correspondence about them. In my opinion, this is thoroughly reprehensible and inexcusable.

THE DUTIES OF A RESEARCH WORKER

These may also be listed, bearing in mind their complementary nature with the duties of the supervisor listed above:

- i. to discuss regularly with their supervisors the literature, the fundamentals, assumptions, the techniques, the calibrations and the planning of the projects;
- ii. to keep detailed notes of all experimental procedures, raw data, read-outs.

- computer print-outs and written notes of any reason for excluding particular values;
- iii. to understand the theory of any procedure or technique they use, including psychological tests, chemical kits and statistical tests. The fact that these are often provided commercially tends to make research workers use them without being aware that every one of them is based on certain theoretical assumptions which one ignores at one's peril;
 - iv. to think about the observations or experiments continuously to try to modify, improve and make cheaper any procedure being used. It is my opinion that this is impossible to do while a radio is playing or while one is wearing a 'walkman'. The phenomena of masking and distraction are well known to psychologists;
 - v. to show the raw data of all the experiments regularly to the supervisor, to discuss why an experiment has failed and to relate any mistakes or misfortunes during observations. During these discussions, the research worker can also draw the supervisor's attention to any publications which he or she has discovered bearing upon the problems;
 - vi. to consult statisticians early during the design of the experiments because, often, they can give advice on how to improve the validity of experiments before it is too late;
 - vii. to attend lectures given by visiting lecturers, not only those relevant to the particular research project but also to the discipline as a whole. The research worker should also go to as many conferences as possible, take notes, and talk and listen to colleagues;
 - viii. to listen to and react to criticism and be ready to modify experiments appropriately.

CARRYING OUT OBSERVATIONS OR EXPERIMENTS

The dates, weighings, location, samples, procedures, chemicals, calibrations, observations, photographs, mistakes, errors, read-outs print-outs, accidents and comments should be recorded in bound paged notebooks. Pilot experiments should be carried out to ensure that the procedure works and to calculate the approximate error in measurements: this error can be used to calculate approximately either how many observations or experiments would have to be done to arrive at a particular significant conclusion *or* what significance may be expected from a known number of observations or experiments.

If the pilot experiments should show that it was not practically possible to do enough observations or experiments to achieve significance, one can look again at the experimental design. One should either increase the differences by, for example, choosing a more sensitive species or a higher dose; or one may be able to increase the number of observations or samples; or one may be able to decrease the variation in the two populations, for example, by selecting a more homogeneous population of human beings to study, or obtaining a purer breed of animals, or by carrying out the observations or experiments more carefully.

Ethical experiments involve being considerate to human subjects, treating animals humanely and adhering strictly to health and safety regulations.

Research workers should always ask themselves the likely results of their experiments. of which there may be four: a parameter may go up significantly; it

may go down significantly; it may not change significantly; it may show so much variability that one cannot decide if any of the other three results is true. The latter requires redesign of the experiment. With a *small* variation, one can say that there is *no* significant difference but, with a large variation, one cannot say whether or not there is any difference and the observations or experiments should be redesigned. An experiment, in which the populations being compared are each so heterogeneous that a significant difference cannot be found, cannot be used as evidence that there is **no** difference.

SUBJECTIVE AND PERSONAL ASPECTS IN RESEARCH

Research workers are not always aware of the many subjective elements in their work because they would like to believe that it is only objective ⁵ (pps. 216-219). Therefore, it is useful to list some of the most important of the former elements:

- i. a desire to please the supervisor, the research establishment, the political power or the source of subvention can be a powerful prejudicial element towards a particular conclusion of research. This is because personal advancement and further financial support for research often depend on one or more of them. "He who pays the piper, calls the tune;"
- ii. different supervisors and research workers know different segments of the literature and decide which they regard as important;
- iii. they each decide how many observations or experiments they will require to prove a hypothesis;
- iv. the research workers may not do the experiments correctly and the supervisors may not carry out their functions sufficiently;
- v. when several different procedures can be used to solve a particular problem, there is some subjectivity in the choice of the particular procedure used;
- vii. motives other than the search for truth may distort experiments or observations;

In addition to these, there are several other subjective factors governing the recommendations of referees and the decisions of editors. The elements of subjectivity bear heavily on the assessment of research. It can be minimized by frank discussion, honest reporting, fair access to publication of novel and challenging views, and repetition of experiments by several groups; editors of journals discourage this as they seek to publish new findings.

PUBLICATIONS OF PAPERS IN ENGLISH

A few general rules of style are worth noting. Simple direct statements, containing relatively few adjectives and adverbs, are easy to read. It is best to avoid the first person and the passive tense. In general, it is easier to read if the main clause precedes subordinate clauses. Simple words, for example, Anglo-Saxon words, are preferred to complex ones, Latin or Greek, unless the latter are technical terms. Enough detail must be given in a publication to permit the reader to reproduce the work and obtain the same result. Therefore manufacturers, suppliers, populations studied, sources of animals and special reagents, and any modification of standard procedures should be clearly indicated. Help should be sought if the author is writing in a language other than his or her own. More detailed instructions on how to write papers have been published ¹¹⁻¹³.

When a paper is to be written, one decides on the journal and makes sure that one is carrying out all the instructions to authors of that particular journal, including how to draw and label figures. The introduction to the paper represents the previous history of the problem and the rationale for the particular project to be described. The methods section describes the population, patients, animals or plants to be studied and the detailed methods to be used. The results are expressed in tables with mean and standard deviations (m+s.d.) with the number of observations for the values (n). One should choose whether to record the information in table or graph form but the same information should not be put in both. The results section should show the units and the statistical evaluations but should not include any interpretation.

The discussion section should include:

- a. correlation of the results of the observations and experiments just reported;
- b. consideration of any advantages, disadvantages and difficulties of the method used;
- c. correlation of the observations and experiments with previous research in the subject;
- d. suggestions for further observations or experiments necessitated by the present ones;
- e. more general implications of the research for the larger discipline.

Acknowledgements should be given to anyone who has helped in the research and provided funds to support it, but one must seek permission from any person acknowledged. References should be listed according to the conventions of the particular journal. Some do not require titles of papers cited and only want the first page of the publication; others require complete titles and first and last page. Some require page numbers of books cited, others do not; most require the name of the publisher and the place of publication.

If the paper is rejected for publication on grounds which seem totally unreasonable to the author, he or she should argue the particular points firmly, politely but seriously. An author has the right to object to the editor about brief, rude or dismissive remarks which are not accompanied by detailed justification of them. However, he or she should respond to criticism responsibly. This may involve:

- a. answering the referees' criticisms;
- b. rewriting and clarifying the paper;
- c. doing more observations or experiments;
- d. if necessary, retyping the paper in accordance with instructions to authors of another journal and resubmitting it;
- e. abandoning the project in light of the criticism. A list of reasonable reactions to criticism is given (Table 1).

It should be said that referees are not always polite or fair. They sometimes give very brief reports or assert that they are too busy to give more detailed criticisms. In my opinion, if they do not have time to be fair to the author, they should not accept the responsibility of being a referee. The same is true for examiners of undergraduate or higher degrees.

Since, after a paper is accepted for publication, a year sometimes elapses

before it appears, often research workers present a brief communication to a learned society which can be within about three months of the completion of the project. This accords the author the opportunity of hearing criticism which can be dealt with in a subsequent full publication.

<i>Referee's remarks about a manuscript</i>	<i>Author's proper reaction</i>
The authors do not understand the problem	Please specify which aspects
The authors have not read unspecified literature	Please indicate which publications and to what problems are they relevant
They have not done some of the experiments they criticize or quote	Neither do most authors; they have a right to quote any published findings
Their arguments have been refuted in the past	Which ones and where?
They do not understand the techniques used in the experiments they criticize	Which aspects?
Unspecified references show that the argument is wrong	Please specify them
The hypothesis is so generally accepted that it is no longer necessary to examine it	This is not a sound philosophy
Your conclusions do not agree with everyone else's in the field	Please specify in detail what is wrong with the experiments or thinking
We do not believe your results	Please indicate in what particular respect, because if you cannot, you have no moral right to take this attitude
The truth will come out	Does this mean that you are unwilling to decide on the present evidence?
Your views disagree with everyone else	Please specify in what particulars

Table 1. Unfair comments by referees unless followed by details with references to particular points. Failure to give reasons for rejecting a paper is even more unfair.

FRAUD

This is the deliberate addition, changing or omission of raw data, calculations, observations or results. It is much more common than is widely imagined^{2-4,14} and is generally deplored. A careful perusal of a paper can often detect it because it is very difficult to hide. One can say that the more senior the perpetrator of it and the more prestigious the publication in which it appears, the more likely it is to be influential. By its nature, it is impossible to know how widespread fraud is.

IMPROPER PRACTICES

However, there are a large number of improper practices which are tolerated and accepted by the academic community, but hardly ever spoken about, and are often

regarded as behaviour acceptable to the research community. It seems very likely that these have much more influence on the corpus of accepted knowledge because they are so widespread and sometimes secret or not admitted. Among these are the following ¹⁵:

1. Research workers do not do all the relevant control experiments either because the supervisors have not thought of them or they have been unwilling to do them when attention has been drawn to them.
2. They do not publish their own results when they are incompatible with their own hypotheses.
3. They ignore the literature with conclusions which are not compatible with their own theories or those whose authors they do not like.
4. They pay lip service to known limitations, artefacts and assumptions inherent in the techniques used but do not take them into account in conclusions or theories.
5. They deliberately omit from manuscripts important details which would permit other research workers to repeat the experiments.
6. They accept or demand co-authorship of papers in research which they did not conceive, carry out, supervise or see.
7. As referees, they recommend the rejection of manuscripts for publication which they *feel* have errors but they cannot identify.
8. They are unwilling to discuss their own published research work with serious interested colleagues privately, publicly or in correspondence.
9. They referee in a hostile fashion manuscripts which produce results with which they do not agree. This is much encouraged by anonymous and peer review ¹⁶.
10. They referee in a hostile fashion applications for grants either by intellectual antagonists or competitors or of those examining problems which the referees do not wish to be examined.
11. They resist the promotion of people who have challenging or 'controversial' views. (The word 'controversial' is put in inverted commas because most new views appear to challenge the general consensus. The label 'controversial' only means that there is more than one serious view but it is intended to alert listeners to beware of other views. It is an emotive term, not bearing on whether the evidence in favour of the 'controversial' view is correct or not.)
12. Congress organizers deliberately do not invite anyone holding views with which they disagree to speak about them at national or international meetings, symposia, congresses or workshops. Sometimes, these others are allowed to put posters up representing their views; perhaps, they are as influential as the wall posters once were in Peking.

RELATIONSHIP WITH SUPERVISOR

It is extremely difficult if one disagrees with one's supervisor. Disagreements may be based on personality clashes, poor supervision, wrong basic training of the research worker, laziness of the worker, a bad project, a disagreement about experiments and other causes. In industry and in academia outside the United States and Britain, a future superior or employer always seeks the opinion of the present supervisor or employer of candidates for a job. Thus, any junior person whom the senior one does not like *for any reason* is very unlikely to find another

job. This results in ambitious people becoming conformist or sycophantic which is not desirable for a thinker. However, no sensible person wants to risk a career or even a livelihood by being intellectually independent. In all countries, a sad fate awaits a student studying for a doctorate who decides to leave before it is completed, for example if a supervisor is not willing to discuss the project, if the supervisor becomes angry about the results or does not have a real grasp of the problem. In general, a student who leaves before completing a doctorate is thought of as being lazy, stupid, awkward or uncooperative - never honourable.

Thus, doctoral students usually have to keep quiet about any doubts they entertain about their projects until their theses have been approved. This can result in cynicism which may be carried on to their later careers. One must encourage scepticism because it is an attitude which improves research but cynicism may lead to fraud and it is wholly destructive. However, it is of crucial importance that the honourable research workers, who have to be quiet about intellectual doubts when in junior positions, should reassert their independence and honesty as soon as they are in a position to do so. This applies with particular force to thinkers and academics under former totalitarian regimes who are struggling to restore freedom of thought.

CONCLUSION

The task of a research worker is extremely difficult and complex. It is very stressful to maintain intellectual honesty as one proceeds with a research project although it can only be an axiom that intellectual honesty will lead to important new discoveries. This would be much aided if logic were taught as an important subject in all academic syllabuses. Intellectual honesty and the exercise of logic should be regarded as necessary elements of professionalism in the pursuit of knowledge.

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