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# Scientific Writing – The Discussion

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# This course

- Content
  - The focus is on writing the discussion for original research
  - We will not be covering the finer details of grammar and punctuation because
    - The biggest obstacle to writing well is organising the ideas
    - I am useless at grammar and punctuation

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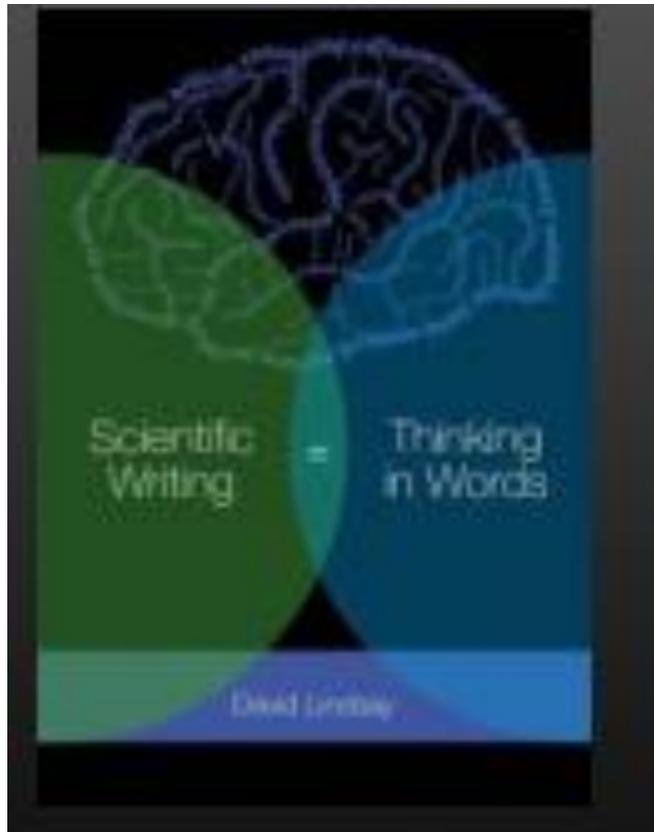
# The course

- The approach
  - Examples have been drawn from scientific papers from a variety of disciplines
  - These sessions work best when there is interaction and discussion so please yell out if something is not clear or you disagree with a point being made

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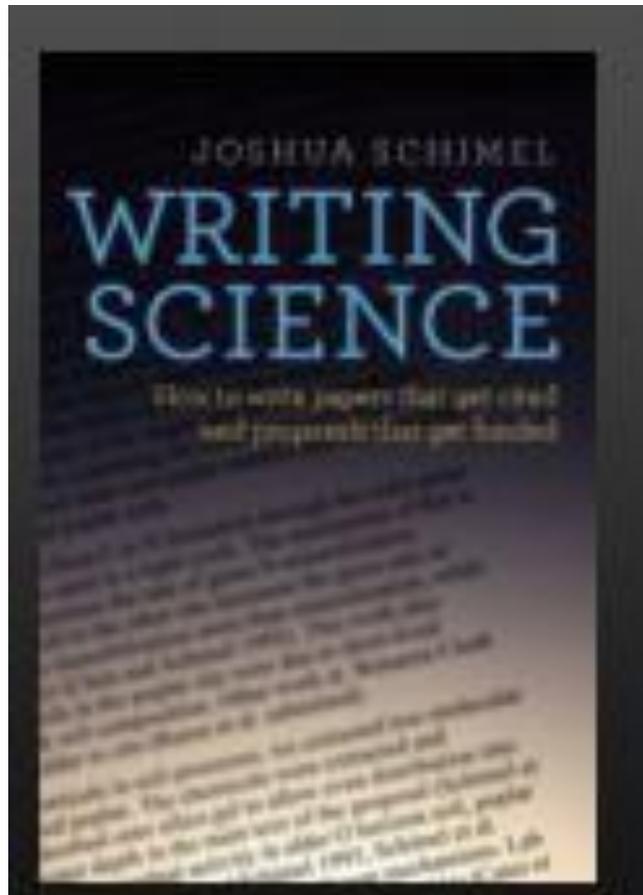
# Roadmap

- Introduction
- Overview of a scientific paper
- What should be included in a discussion?
- What to avoid in the discussion
- Giving impact to your discussion
- [I hope] Helpful hints



Scientific Writing = Thinking in Words by David Lindsay

This book makes for easy but insightful reading. Some of the points may not be appropriate for all scientific papers and there could be more examples. However, there will still be enough in there to challenge you



## Writing Science by Joshua Schimel

This book focuses on the art of writing good scientific papers as well as funding proposals.



## Essentials of writing biomedical research papers By Mimi Zeiger

Don't be put off by the "biomedical research". The book covers the nitty gritty of sentence structure as well as the bigger picture issues. There are lots of examples for different scenarios as well as an excellent section on how to present data in tables and figures.

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# Introduction

- Generally speaking we conduct scientific research:
  - To test a hypothesis
  - Describing something e.g.
    - The structure of a [newly discovered] object such as a bacteria
    - Spread and/or impact of an infectious agent
  - Exploring a new method e.g.
    - An improved method or technique for extracting DNA or growing a bacteria
  - Proof of concept for a statistical approach

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# Introduction

- Many of us [including me] prefer other aspects of science over writing
- But we need to write otherwise we might as well have not done the research
- If we really want our research to have an impact then we must make the job easier for the reader

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# Group Discussion

How do you approach the task of reading scientific papers and technical reports?

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# Group Discussion

Who are the readers of technical reports  
and peer review papers?

Writing clearly does not just benefit your reader, it helps you clarify your own thinking. For those of you with supervisors it helps them understand what was done.

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# Roadmap

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# Overview of a scientific paper

- Introduction
  - Series of logical steps that explain the problem or rationale for the study
  - Ends in a statement of what the research is about, why you did it and what you expected to get from it.
  - If you have done your job well then readers will be [relatively] enthusiastic about the contents of the paper

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# Overview of a scientific paper

- Materials and Methods
  - You need to describe what you did in a way that a competent colleague could replicate the study
  - Great place to actually start the writing process as you are describing what you did

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# Overview of a scientific paper

- Results
  - Describe what you found in relation to the hypothesis of the research
  - If something unrelated to the hypothesis and interesting was found then we may include that
  - We must separate out the results from the discussion

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# Overview of a scientific paper

- Discussion
  - In the discussion we have a chance to explain:
    - What was the point of all the work?
    - What the results mean
    - If the results answered the question

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# Group Discussion

What should we include in the discussion of a technical report or peer review paper?

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# What should be included in the discussion?

- The following topics should be covered:
  - The major findings
  - Meaning and importance of your findings
  - Discussion [not just description] of how your results relate to other studies
  - Acknowledgement of study limitations [and how this might have impacted your results]
  - Non-causal explanation for your finding
  - Future research
  - Take-home message or conclusion

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# What should be included in the discussion?

## The study's major findings

- You will find it difficult to complete this if you did not have a clear rationale for the study
- We can do this by saying:
  - This study shows that...
  - Our results indicate that...
  - In this study, we provide evidence that...
  - In this study, we found that...
  - In this study, we have found that...

The experiments presented here show that cloned human tumor necrosis factor  $\alpha$  inhibits the expression of MYC in the human promyelocytic leukemic cell line HL-60 selectively and that it does so by decreasing the rate of synthesis of MYC mRNA. Evidence that the inhibition of MYC gene expression is selective is that expression of mRNA for reference proteins HLA-A, -B, and -C was not inhibited. In fact, transcription of HLA-A, -B, and -C mRNA was slightly increased (Fig. 5). Evidence that the rate of synthesis of MYC mRNA decreases is that the half-life of degradation of MYC mRNA remained unchanged in cells treated with cloned human tumor necrosis factor  $\alpha$  (Fig. 4) and that in nuclear “run on” assays, cloned human tumor necrosis factor  $\alpha$  decreased the rate of MYC gene expression.

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The hemodynamic data obtained in this study indicate that in the open-chest living dog a waterfall effect occurs in the large pulmonary veins where they exit from the surface of the lungs. Its presence has been demonstrated in two ways. First, the finding that upstream intrapulmonary venous pressures were influenced by changes in downstream extrapulmonary venous pressure at high but not at low downstream pressures is consistent with the concept of a pulmonary venous waterfall effect between the two measuring sites. Second, we found that, under conditions of physiological flow, when the downstream pressure of the pulmonary veins was zero, there was a short segment where the vein was leaving the lung in which intravascular pressure changed sharply from a positive upstream to zero downstream pressure.

Zeiger, Mimi (1999). *Essentials of Writing Biomedical Research Papers*. McGraw-Hill Professional.

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# What should be included in the discussion?

## The meaning and importance of the findings

- We often think that this should be obvious but you have spent more time thinking about the study than anyone else
- Take the reader by the hand and explain why the study's findings are important

Regardless of the reason for the difference, the results highlight the need to invest resources into updating Agribase if it is to be used to identify equine properties during a disease outbreak.

**When designing future surveys it would also be worth considering using phone interviews rather than a mail out survey.** Firstly, the phone survey in this study had a higher response rate. Secondly, a phone survey has the advantage of allowing interviewers to clarify any issues with the data at the time of collecting the information. Phone surveys may also reduce the resources required for data entry if interviewers are issued with a headset, and log responses directly into a database.

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# What should you include in the discussion?

## How your results relate to other studies

- We need to explain how our results relate to the wider scientific audience

By using whole mounts stained histochemically for acetylcholinesterase, we have reconstructed an overall picture of the architecture of the nerves and ganglia of the trachea in ferret. **This reconstruction, which incorporates and confirms the separate observations of previous investigators<sup>6, 9, 11, 14, 24</sup>, includes several new observations** that provide a more complete understanding of the tracheal innervation.

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# What should you include in the discussion?

## How your results relate to other studies

- When citing other peoples work remember:
  1. The discussion is not a review of the literature review
  2. The focus is on your results and how the published work relates to that

# Which is better?

## Option 1

Green (2005) found that spraying copper prevented leaf spotting, but Black (2006) found there was no association. The current study found no association so my results support those of Black

## Option 2

The current study found no association between spraying copper and leaf spotting, and, therefore supports work by Black (2006). However, the results do not agree with those of Green (2005) who found that spraying copper did reduce leaf spotting.

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# What should you include in the discussion?

## How your results relate to other studies

- When my results differ from published literature can I just say we disagree?
- No you should offer up a reason for why there might be disagreement

The results are consistent with previous research by Mason and Bourke (1973), Bailey *et al.* (1999) and Perkins *et al.* (2004a) but differ from a UK study... The difference between the current study and Rosedale (1989) may be due to a number of factors such as regional differences, differences in case definition and study population. For example, the study population in the Rosedale study included horses of all ages, while the current study was restricted to two- and three-year-olds.

Naomi Cogger (2006). Epidemiology of musculoskeletal injuries in two-and three-year old Thoroughbred racehorses

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In this study, we found that, at 37°C, alveolar surface tension at total lung capacity is  $29.7 \pm 5.6$  (SD) mN/m. We believe that this value, which we determined by a direct technique, is accurate because it is close to the known equilibrium surface tension of about 25 mN/m for extracts containing pulmonary surfactant (10, 11). **However, higher surface tensions have been suggested by other investigators, who did surface balance studies of lung extracts.** Their values range from 31 to 50 mN/m (7, 8, 12). But deducing values for alveolar surface tension from lung extracts in surface balances is uncertain, because the actual concentration of surface-active agents at the alveolar surface is not known (5, 13). **We suspect that the concentration of surface-active agents in lung extracts as usually assessed in surface balances might be lower than those in alveoli at total lung capacity and that if higher concentrations were used, surface tension values deduced from surface balance studies might be closer to equilibrium values.**

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If you really can not think of a reason why there are differences, it would be better to say something like

‘There is currently insufficient information about X or Y to be able to determine the reason for these differences.’

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# What should you include in the discussion?

## How your results relate to other studies

- I can not relate my research to other studies because:
  - My research is so cutting edge
    - Science does not happen in a vacuum so the idea must build on some research
  - The pest or disease has never been studied in New Zealand
    - Have there been studies overseas or is there a related species that you could compare your results with
  - I can not download the papers
    - Walk over to the library

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# Group Discussion

Does a technical report need to include reference to other studies?

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# What to include in your discussion

## Consider alternative explanations of the findings

- [Typically] alternative explanations when the results are a surprise
- Remember the purpose of research is to discover rather than prove so we need to consider alternatives even when the results are expected

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# What to include in your discussion

## Consider alternative explanations of the findings

- I ask myself the following questions:
  - Could the results be due to the way in which we sampled?
  - Could the results be due to the way in which we measured the key variables?
  - Could the results be confounded by an unmeasured variable?
  - Could the results be due to chance?

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# What to include in your discussion

## Acknowledge the study's limitations

- All studies have limitations
- It is far better you state the limitations

Despite the potential for misclassification, it was considered preferential not to rely on confirmation by a veterinarian, as this may have resulted in an underestimation of MS injuries because common conditions such as shin soreness are often not seen by a veterinarian (Perkins *et al.* 2004a).

**Musculoskeletal injuries were primarily categorised on the anatomical location of the injury in an attempt to minimise the misclassification bias. However, the estimates for some injuries may still have been affected. In particular, tendon and ligament injuries may have been underestimated if they were misclassified as fetlock or carpal joint problems.**

Naomi Cogger (2006). Epidemiology of musculoskeletal injuries in two-and three-year old Thoroughbred racehorses

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# What to include in your discussion

- Make suggestions for further research
  - It is pretty much a given that your work will lead to more research so don't just end with “more research is needed”, be specific
- Give a take-home message
  - This is not the place to simply re-state your findings

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Fruit picked in the early summer, not only lacks the colour of later-picked fruit but it is lower in soluble carbohydrates

We should add some conclusion...

If fruit is to be sweet enough to process it must not be picked before mid-July.

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In conclusion, our data suggest that Y-phosphorylated p27 can inhibit cyclin D-cdk4 complexes by two independent mechanisms: blocking access to the T-loop and disrupting the cdk4 active site directly. Our model suggests that p27 Y phosphorylation is a molecular “switch” that would help turn cdk4 activity on or off . Modulation of Y kinase activity would permit activation of preformed, inactive p27-cyclin D-cdk4 complexes by cdk7 and may be used to regulate cdk4 activity throughout the cell cycle.

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## How could we improve this?

A proteomic evaluation of hummingbirds under simulated migratory conditions revealed evidence of several stress-associated processes: protein degradation in wing muscle tissues, depletion of metabolic cofactors, and enhancement of stress-response proteins. These results suggest that changes in the hummingbird proteome may provide new insights into the complex physiology of avian systems biology.

Schimmel, Joshua (2011-11-01). *Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded* (Page 88). Oxford University Press. Kindle Edition.

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**While hummingbirds migrate long distances over water without feeding or resting, it is physiologically stressful, and the birds' ability to manage this stress may limit the distance they can migrate.”**

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# What to avoid in a discussion

## Over presentation of the results

- Remember the discussion is read in conjunction with the results
- It is difficult to read a paper when there are lots of numbers
  - Really you should not be quoting any more than one or two numbers
- If you find that you are having trouble writing the discussion without re-quoting the results this is a sign you need to re-write the results

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# What to avoid in a discussion

## Inflation of the importance of the findings

- When explaining the importance of the findings care must be taken not to overstate.
- While a little humility is important, in my experience [early career] researchers typically undersell the importance of their findings

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# What to avoid in a discussion

- Unwarranted speculation
  - This is one of the more controversial areas

## **Group Discussion**

A trial found that application of a new fertiliser increased productivity in apple trees by 30%. Could you speculate as to what would happen if it was applied to pear trees? What about kiwifruit?

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# What to avoid in a discussion

## The “bully pulpit”

- Science is an iterative process, so do not use the discussion to be overly critical of other studies
- Remember 20 years from now your work might not look crash hot either

## Conclusions that are not supported by the data

- Avoid the temptation to allow your biases to enter into your conclusions

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# Giving impact to your scientific paper

- Newspaper editors tell us what the big story of the day is by:
  - Putting it on the front page
  - Giving it more space than the lesser news
  - Use of headlines that are often colourful or dramatically worded
  - It may be associated with eye-catching pictures or illustrations

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## Giving impact to your discussion

- How does all of this relate to your writing a discussion?
  - Some of the discussion points are more important than others.
  - You need your readers to know what are the more important points
  - We should structure our discussion so that those reading only the first few lines will grasp our main message.
- Therefore the key to a good discussion must lie in a system to prioritise the points you want to make

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System used to categorise ideas for inclusion in the discussion of a paper. From Lindsay (2011). Scientific Writing = Thinking in Words

Category	Description
1	Relevant to the original hypothesis and allow you to make a positive statement of acceptance or rejection.
2	Relevant to the original hypothesis but which for some reason are equivocal, or suggest further experimentation or observation before acceptance or rejection.
3	Not relevant to your original hypothesis but which you consider sufficiently new or interesting to be worthwhile including.
4	Those arguments based on your results, not relevant to your hypothesis and of marginal interest.

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# Giving impact to your discussion

- Lets revisit how newspaper editors tell us what the big story of the day is by:
  - Putting it on the front page [well earlier in the discussion]
  - Giving it more space than the lesser news.
  - ~~– Use of headlines that are often colourful or dramatically worded.~~
  - ~~– It may be associated with eye-catching pictures or illustrations.~~

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# Giving impact to your discussion

## Positioning of your points

- Put your most important points first and the least important last.
- Don't save the most powerful argument to make an impressive finish
- Often readers don't read the full article, but if they find interesting stuff in the first paragraph of the discussion they may be more likely to keep reading.

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# Giving impact to your discussion

## Giving more important points more space

- Readers automatically relate amount of text devoted to an argument to its importance.
- What can you do if your most important point is the most simple to develop and a minor argument takes three-quarters of a page?

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*“[Treat ] being a writer as something a scientist is,  
NOT something a scientist does.” Schimel (2011).*

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## Helpful tips

- Don't separate out writing from the lab or field work
- Have a draft report, thesis chapter or paper going when you begin the work
- Every time you talk to someone about your study see it as a chance to make notes of issues that could be included in the discussion

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## Helpful tips

- Keep notes of :
  - Results that you or others found particularly interesting and why
  - Results that were confusing
    - Even if there was a reasonable reason for them, this is something your readers are also likely to pick up on
  - Findings that support or contradict other findings
    - Make sure you note down details of the previous work
  - Any limitations to the study
  - Discussion about future research or wider implications

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## Helpful hint

- If you really want to improve your writing:
  - When you read papers, look at the style and when you find one you like make a note
    - People who are leaders in the field are often good writers
  - Start a writing group

## **A note about the review process**

As an author I can not think of a single time when the reviewers comments have not improved the quality of the paper or report. So when you get a critical review see it as saving you from a more public mistake.

When I review a paper my goal is see the paper or report improve. Sometimes that means that more work may be needed either in the lab or on the manuscript. While this may be frustrating, my goal is not to inflict pain but to improve the quality of the paper.

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Shitty First Drafts. All good writers write them. That is how they end up with good second drafts and terrific third drafts.

I know some very great writers, writers you love who write beautifully and have made a great deal of money, and not one of them sits down routinely feeling wildly enthusiastic and confident. Not one of them writes elegant first drafts. All right, one of them does, but we do not like her very much.

Anne Lamott (quoted in Schimel 2011)

This paper reports on the working environment, breeds, sex, and reproductive and life cycle of livestock herding dogs in the Manawatau-Wanganui region of New Zealand. Several of the design features of this survey contributed positively towards the internal validity of the study. By gathering data pertaining to all livestock herding dogs that had been on the farm over the preceding 12 months, irrespective of whether they had died or moved off the farm, the study was not bias towards those with favourable survivorship. Further, inclusion of livestock herding dogs that had yet to be trained, that were semi-retired or that were retired meant the study did not exclude LH dogs that were not currently working. Still, it is unlikely that the internal validity of results of this study were not affected by obsequiousness or response bias. Given the sensitive nature of some of the questions, in particular questions about the cause of death of livestock herding dogs and information about pups born on the farm, it is possible that some livestock herding dog owners gave answers they believed to be more socially, legally or politically acceptable or avoided reporting the truth. Although 31 livestock herding dog owners did not report the cause of death for 38 livestock herding dogs, 57 (28%) livestock herding dog owners reported breeding at total of 768 pups of which 464 (60%) had died or been destroyed, suggesting the impact of obsequiousness or response bias may be minimal.