m Anno 2008_Numero 04

miscellanea INGV

Professional Writing for Scientists

04

Istituto Nazionale di
Geofisica e Vulcanologia

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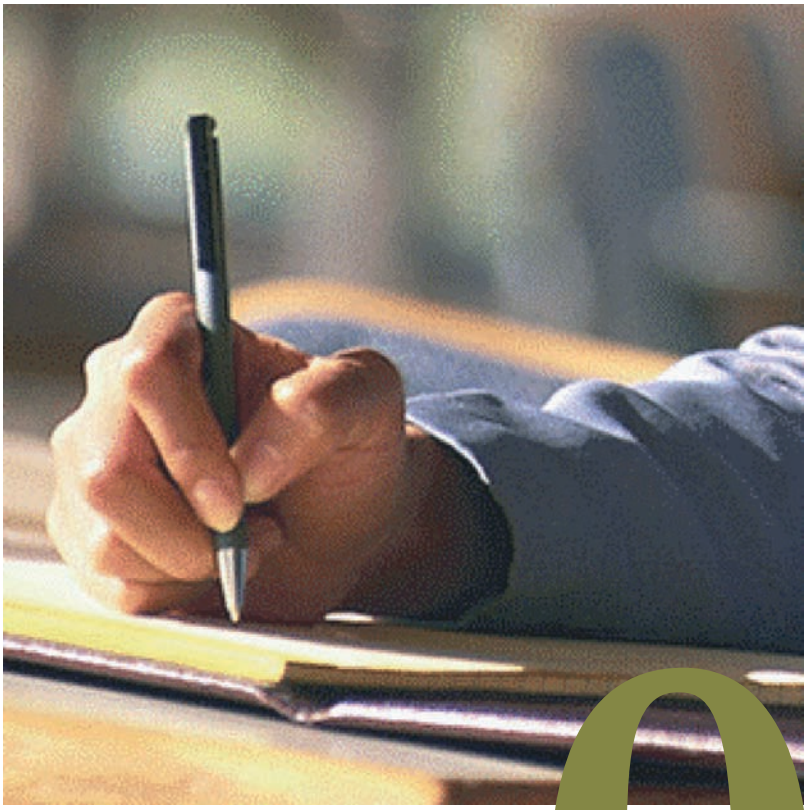
Miscellanea INGV

PROFESSIONAL WRITING FOR SCIENTISTS

di Kathleen J. Jackson ©2003

a cura di Gloria Livoli e Gianluca Valensise
INGV (Istituto Nazionale di Geofisica e Vulcanologia- Roma)



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Preface

A cat is said to have nine lives. I hope the following nine lectures, originally given at INGV in Rome (2003), will have similar longevity and better yet, use.

It was my great pleasure to collaborate with supervisor Dr. Gianluca Valensise in this project for European geoscientists. My husband, Professor David D. Jackson, also helped in untying or at least unraveling difficult, knotted concepts.

My hope was to break down into manageable units the challenges of making English a tool for clear, memorable exposition. After scanning many papers written by scientists whose native languages were not my own, I isolated certain common problems. Each lecture addresses these pitfalls in a loose order of ascending difficulty.

The British poet, Lord Byron, once complained of another speaker/writer: "I wish he would explain his explanation." These lectures should protect you against that too common charge.

Best wishes in your pursuit of clean, colorful and complete English. Remember that good writing aids and attests to good thinking!

No matter how good your findings, they must be presented well. These pointers will help you compose your data into a more polished whole.

Dr. Kathleen Jackson

Nota degli editori

I testi raccolti riproducono fedelmente le dispense utilizzate da Kathleen (Kathy) Jackson durante una serie di dieci seminari svolti presso l'INGV tra il 15 gennaio e il 19 marzo 2003. I seminari, che erano aperti a tutti, ebbero un notevole riscontro di pubblico - da un minimo di alcune decine a oltre cento presenti - e si basavano su casi, quesiti e problemi di stile di traduzione segnalati dal pubblico stesso. Lo stile delle lezioni era informale, e Kathy faceva frequente riferimento a situazioni contingenti e oggetti che portava con sé in sala per rendere più varie e interessanti le lezioni. Kathy si è anche preoccupata di massimizzare l'impatto delle lezioni e l'aderenza degli esempi ai casi effettivamente incontrati dal suo pubblico nella pratica quotidiana. Per questa ragione le lezioni contengono e analizzano brani tratti da articoli realmente scritti ricercatori e tecnologi dell'INGV, evidenziando errori e proponendo migliorie nella struttura delle singole frasi e nella scelta delle parole. Per aiutare il lettore abbiamo quindi utilizzato ovunque le seguenti convenzioni:

- il testo normale è riportato con font normale (non corsivo);
- le frasi tratte da articoli sono virgolettate e riportate in corsivo;
- i concetti a cui Kathy ha voluto assegnare particolare importanza sono sottolineate o, subordinatamente, in corsivo;
- il colore rosso identifica frasi che contengono errori;
- il colore verde identifica frasi corrette dal punto di vista linguistico. Frasi in rosso e verde sono di solito associate. Si noti che in molti casi vengono proposte più formulazioni corrette ("verdi") di uno stesso passaggio errato ("rosso").

Grazie alla sua curiosità per le culture e per le lingue lontane dalla propria - e in particolare per quella italiana - Kathy ha saputo cogliere differenze nello stile espositivo che nascono proprio dalla diversità intrinseca tra l'italiano e l'inglese. In questo senso queste dispense offrono stimoli e propongono punti di vista che ne fanno molto più che una semplice guida ad una corretta stesura di un testo scientifico in inglese.

Buona lettura!

Gloria Livoli e Gianluca Valensise

Lecture 1

Where to Put What? Placement: 4 skills

Good writing is like good teaching: both are performances which create and enforce remembered information. To do that in teaching, I often use props as they would in the theater. Today's prop is a hat. Why? Because as professional scientists, you often, as we say, wear many hats: experimenter, researcher, mathematician, proposal/grant writer, teacher and map maker. A colloquial name for this series might be "How to put on your English language hat." I brought an American cap because American English is my specialty. It's designed to remind you to wear a new style when writing and speaking in English. I will try to help you acquire that style through revision techniques on micro and macro levels.

Here's the first hard truth to face: using English vocabulary cannot in itself make your Italian writing "English." Instead the vocabulary must take on an English structure. One key way to make it sound and read "right" is mastering placement: where to put what. Remember that the art of persuasive writing is called "composition"or placement with. This skill is especially crucial for English because that language has lost most of its former inflections. Without them, readers must deduce meaning from where the unit is placed. The rule of thumb is to place the modifier as close to the modified as possible - I'll call this "skill one." If you neglect this rule, readers cannot figure out the logical flow of your intended meaning. Unlike English, languages that have preserved more inflection, like Italian, can be more fluid or flexible in where words can go. Also because non-inflected English makes the placement of units key, those units (words, phrases, clauses) cannot get too long or the reader will run out of "interpretive gas." Consider the analogy of wave theory: the reader can't decipher the meaning relationships when placement and length destructively interfere. I will discuss this issue of length in later talks and focus on placement here. Another analogy, this time with math, might help: consider how meaning in a formula changes with a misplaced value: (, or [. The same is true when writing English.

Let's start with a few examples. The key is making form follow content so that logically related ideas are linked spatially on the page. Simple translation: put modifier and modified as close together as possible whether they be noun and adjective, verb and adverb, subject and predicate, or main and subordinate clauses.

1. A good case in point: *"to avoid distorted phases by scattered energy"* should be: *"to avoid phases distorted by scattered energy" (place complete and uninterrupted adjectival clause by noun it modifies - "phases").*

2. Compare an easy non-scientific pair using the dangerous adverb "only":
   "I love only you" with *"I only love you..."* (The first is a statement of loyalty and the second says: *"I may not like or respect you very much! Love is the only feeling I have for you"*). The emphasis is quite different.

Now compare subtle placements of the modifier only in science:

a. *"His results on the eastern Aegean Sea are constrained only by gravity data."*. (No other data exist and that weakens the results; emphasis on gravity data.)
b. *"His results on the eastern Aegean Sea are only constrained by gravity data."* (The gravity data put bounds on interpretation but cannot define - emphasis is on "constrained.")
c. *"His results on the eastern Aegean Sea are constrained by gravity data only." (This is* like a. but emphasizes the singularity of the data as the last word; it's all we've got and isn't enough!)
d. *"Only his results on the eastern Aegean Sea are constrained by gravity data."* (Researcher d. is anomalous!)
e. *"His results on only the eastern Aegean Sea are constrained by gravity data."* (Only the sea is emphasized, not the researcher this time. Perhaps his results elsewhere have additional restraints.)

This very tricky placement of *"only"* emphasizes or isolates what comes right after it or, if it is the last word, itself.

Decide on your focus!

3. Here's another example of the unintentionally comic effect of misplaced modifiers. This one comes from an official pamphlet on Palazzo Doria Pamphili:

"Among the several masterpieces still preserved in the collection, the portrait of Innocenzo X ordered by Velazquez and the bust ordered by Bernini stand out." (This becomes funny because it inverts the power relationship between the patron pope and the dependent artists. They made but did not order the art works).

How to fix? Perhaps:

"Among the several masterpieces still preserved in the collection, those ordered by Innocenzo X stand out: the portrait by Velazquez and the bust by Bernini."

Or we could say:

"Among the several masterpieces still preserved in the collection, the portrait by Velazquez and the bust by Bernini, both ordered by Innocenzo X, stand out."

4. To put us back in the realm of science, here is an example of ambiguous placement whose uncertainty comes from this question: with which part of the preceding main clause does the modifying phrase go?

Listen to this: *"Calcareous bedrock horses have been exhumed from the debris cover, due to erosion and to extensive quarrying."*
Now does this mean that it was easy to exhume the horses because of erosion and quarrying, or does the modifying phrase explain how the debris cover happened?
If the former, I would say: *"Erosion and extensive quarrying made it easy to exhume calcareous bedrock horses from the debris cover."*
You want to eliminate any confusion so that geophysicists can understand too! And most important: you want no confusion in readers to undermine their attention for your most important ideas. Remember: any "loose end" in writing tells readers that your thinking is not tight/rigorous.

Here's one more example of the ambiguously placed modifier, a single word this time.
Consider: *"We found that the data fit our model, which explains extension in the basin and range excellently."*
What is the confusion here? We answer with a question: Which part of the preceding sentence does the adverb "excellently" modify? Is the model excellent at explaining, or do the data fit excellently?

A Possible Fix: *"We found an excellent fit between our data and model, which explains extension in the basin and range."*
Now you have no more "loose cannon" of meaning.

A very common misplacement is called a dangling modifier. It happens when there is no agent in the main clause to do the action in the phrase or clause perched before it. The modifier dangles there like a trapeze artist hanging by one foot with no safety net. Here's an invented example to help you remember this mistake:

"Hiking in the Caffarella Valley one morning, the bird startled us.". (Here the structure of English - which assumes that a logical bond exists between words juxtaposed - struggles against the absurdity of a bird hiking. There must be an agent in the modifying phrase, or the subject in the main clause must match the phrase.

Here are corrections in that order:

- *"As we hiked in the Caffarella Valley one morning, the bird startled us."*

or

- *"Hiking in the Caffarella Valley one morning, we were startled by the bird."*

The second skill of placement is to center the main idea in the right part of speech. That special part in English is the verb. The verb energizes writing and is thus particularly needed in scientific discourse, which is so laden with abstract nouns. Studies of how people remember what they read show that interactive or participatory reading stays longest in the mind. If readers are made to imagine action through an active verb, they are more engaged in the thought and can retain it longer, just as we remember question and answer sessions better than straight lectures where we passively listen.

Here are some examples of how active verbs can "juice up" your scientific writing:

- *"is in agreement with"* becomes *"agrees with"*
- *"they are indicative of"* becomes *"they indicate"*
- *"For interpolation between"* becomes *"To interpolate…"*
- *"The aim of Figure 2 is to outline"* becomes *"Figure 2 outlines…"*
- *"can be assumed to be in excess of"* becomes *"can be assumed to exceed"*
- *"we present a summary of"* becomes *"we summarize"*

In each of these cases I have taken the main thrust and put it into verbal form.

For a longer example which is only part of an already lengthy sentence, compare:

- *"The second phase of GHSAP is devoted to the completion of work in selected test areas for multinational, multidisciplinary seismic hazard assessment…"* (22 and still counting rather long, abstract words). Keyed to "devoted to".

With

- *"In the second phase of GSHAP, we will complete multinational, multidisciplinary work in test areas to assess their seismic hazard."* Keyed to the energies of complete and assess (20 words) and shows better the relation between test areas and hazards.

You can play with that order depending on the emphasis you want. For example, try "multidisciplinary work to assess seismic hazard in test areas…"

Here is another overly long example which has chosen *"proceeding with"* as its main verb idea and buried the ideas of compiling and assessing as nouns in a prepositional phrase:

- *"This five-year program, initiated before the FSU break-up and interrupted during the period of more intense political turmoil, is now proceeding with the compilation of a catalogue and the assessment of hazard, using for the first time a probabilistic approach."* (40 words and often long, abstract ones)

Compare:

- *"Begun before the FSU break-up and later interrupted by more political turmoil, this five-year program is now compiling a catalogue and for the first time using probabilities in assessing hazard."* (30 words)

NOTE: This is an improvement as well in getting key ideas like probability, assessing and hazard closer together, dancing cheek-to-logical-cheek. I also prefer the subject and predicate more closely linked on the

page because the sentence is complicated.

Putting the idea in the right syntactical unit is a third task of placement. For example, one shows a main idea by putting it in the main clause, never in a subordinate clause or worse yet a prepositional phrase. Readers deduce how important something is to you by the grammatical power you've given it. Don't mislead them by burying your key point!

5. Often people start with: *"It should be noted that…"* and the key thought follows in a dependent clause. If possible, drop *"It should be noted"* as your main clause and *"cut to the chase"* as they used to say of old keystone cop movies. Use your budget of main clauses - the power units - for main ideas.

Compare:

• *"It should be noted that several bilateral and multinational projects are conducted on different continents independent of GSHAP."* 18 words beginning with 4 "filler words"

with:

• *"On several continents bilateral and multinational projects are running independent of GSHAP.* Here we have 12 words with a more energetic verb and the main idea is in the main slot.

I also like getting the parallel projects closer together on the page for comparison; in the original 7 long words separated the two kinds of programs. Four shorter words separate the two in the second version. In that way the reader understands what is important and linked logically because it is so in the text.

The last placement skill again turns on studies of readers' retention. People usually remember best what comes first and last in any unit, whether it be a sentence, paragraph, section, chapter, or book. Your job as a skillful writer is to prioritize your ideas first and lay them out in your piece in that persuasive order. The middle will drop out so place the key thoughts first and/or last. The only exception to this rule is when a thought unit is long; by the time readers come to its end, they will have lost thinking and assimilating energy. Only then is the last slot weaker. Let's look and listen to some examples - your eye and ear will tell you what works better.

Compare:

• *"Seismicity is essentially a random phenomenon."*

with

• *"Seismicity is essentially random."*

The first 6 word version is not incorrect but rather colorless. It focuses our attention on seismicity/phenomenon.

By contrast, the second version emphasizes the seismicity/randomness link and is punchier/stronger because it is also shorter.

Once you have decided which word is key in your first draft, then end on it. It will have the effect of a solid landing in gymnastics, a splashless dive, or a perfect dessert. Don't go beyond the key word to dissipate its energy: that mistake would be like adding ever more water to coffee grounds to make better coffee. Or once you have underlined the key word in your draft sentence or paragraph, begin with it, as in "seismicity." That has the power of the antipasto when you are most hungry. Either way works and their combination is very powerful.

Compare the following:

• *"Could this rather anomalous earthquake be considered a random or extremely rare event?"* (13 words)

with

• *"Could this quake be considered random or extremely rare?"* Better! Why? Only 9 words to remember and emphasizing random/rare rather than *"event."* Rule: get the key words closer together and begin/end on them!

NOTE: "anomalous" was somewhat redundant with *"rare."* What was very good about the sentence is its question format and use of linking sounds in the "r" of the linked concepts, random and rare. Very strategic!)

Conclusion: I'd like to take us back to our prop for a minute: I know that many of you wear the hat of "map-maker." Let that help you think about strategic placement in composition, since writing in every language - not just English - is a form of mapping that helps readers find your individual thoughts and their interrelationships. In many languages inflections supply that road map. But in English, you must place thoughts in the right spots on the "word map" to highlight important "topographical features" for your readers/listeners.

To drill in today's thesis: remember that English is what linguists call an "analytic" language in which one analyzes or deduces meaning largely from where the chosen word, phrase, clause, paragraph, or section "lives." So think placement when you wear that English hat. Remember in your own language that "caro/cara" takes on a very different meaning when it precedes or follows a noun! Use that as a model for what usually happens in English.

Practice Period:
Take any three sentences from a paper you are writing or reading in English to practice these skills. It would be best to use a new set of three for each task. It will help you to underline first the key thought you wish to highlight in each sample.

Is the key idea close enough to its logical neighbors?
Can it be given in verb form?
Is any modifier dangling away from its proper syntactical anchor?
Is it located at the beginning, end or better yet, both slots?

Answer each editing question separately to isolate the problem until you become more fluent in revising! Read the sentences out loud both before and after editing to compare their effectiveness. The eye and ear are a great critical team.

Lecture 2

More on Placement: How to Frame your Ideas

Here is today's menu of skills:

Skill one: Letting Cause help you: logical signposts on your writing map

Skill two: Letting Chronology help you

Skill three: Letting Spatial Connections or transitions help you

Skill four: Using inductive or deductive patterns: moving from small to large, or large to small

I understand from our last session that some of you did not know the noun *"prop"* that I had used for my hat. It is short for *"property"*: a theatrical object which gives a sense of reality and conveys meaning. So it is a good tool or metaphor for writing which can serve the same purposes. Today's prop is a picture frame because I will address how placement provides context for or frames your ideas.

As we have learned, the first and last slots of any thought unit are strongest. If that is so, how should we order two equally important ideas? Does it really matter which goes first? In many cases it does. The four skills listed above address those cases.

Skill One: Letting cause help you means organizing words on the page to show the order of your reasoning. Think of the "if-then" mathematical model. Put *"the why"* first. Try using the following phrases and clauses:

Given this evidence (always singular - a collective)
Based on these data (plural)
For the above reasons, we conclude/find…
If this is true, then we conclude…
Since liquefaction occurred there, we find
Because little is known about…, we assume
Since correlating these surfaces is difficult, we tried relating them to other geomorphic elements.

Here is an example that could use fine tuning:

"To simplify the discussion in the text and figures ages are reported adjusted to…"
I put this in green because the example is for the most part good. It puts the *"why context"* first to orient readers on the word-map.

However, it would be better as:

"To simplify discussion in the text and figures, ages are reported…"

How is this as an improvement?

1. We omit the first definite article *"the"* to save its impact for *"text and figures"* because *"the"* works just like *"only."* Both isolate and feature what comes right after them. *"Discussion"* has the meaning *"in general"* and

is not as important as *"text and figures"* here. For both reasons, it can and should be left out.

Whenever possible use the definite article as this tool of focus.

2. Adding a comma after figures is required because it prevents confusion. It tells where the main clause begins: *"ages are reported..."*. Introductory matter of some length needs a comma after it to show the logical break between preliminary context and dominant idea.

Here is still another example of providing a logical frame. Does it help the reader enough?

"We suggest that this liquefaction is related to the 1627 earthquake, based on the upper extent of the sand dikes."
This version puts conclusion before evidence, the cart before the horse. Try instead the horse before the cart:

A. "Based on the upper extent of the sand dikes, we suggest that this liquefaction is related to the 1627 earthquake."
Version A. gives the logical context first: given the evidence of the first nine words, we can then conclude a relationship between liquefaction and the 1627 event.

That is how scientists think: setting up a hypothesis, testing it against evidence, and drawing conclusions.

It also improves upon the original by delaying the word "liquefaction" more: in the first passage from which I took it, it was mentioned twice only 4 words apart. That can get boring.

I also draw attention to the phrase *"is related to."* It is a fine expression if you are uncertain about the degree of cause, but if you mean that the event caused the liquefaction, it would be more precise to say so. We will talk more about precision later, but start thinking about the word *"suggest"* now. Are you more certain than that? If so, say *"we conclude"* or *"we find."*

Finally, the original has some ambiguity: the phrase *"based on…"* seems to modify *"earthquake"* because it directly follows that word. I think the authors meant the phrase to modify instead the whole clause preceding it. But English structural rules fight against their intent. However, if we reorder the sentence to put the horse before the cart (reason first), we avoid this unintended vagueness (a simple fix).

I recommend doing a word search on your first draft, looking for *"based on"* or *"given by"* just *"by"* so that you can check how facts and evidence are connected. Is that connection in the right order/placement so that no ambiguity occurs?

One other way to clear up this confusion is to add a clarifying noun before *"based,"* as in:

B. "We suggest that this liquefaction is related to the 1627 earthquake, a conclusion based on the upper extent of the sand dikes."

Adding that noun tells the reader that *"a conclusion…"* modifies all 11 words preceding it. I prefer the tighter version of the fine tuned A myself. But you must make your informed decisions.

Skill Two: Letting chronology help means putting first on the page what came first in time. Recipe instructions and how-to manuals are good models of this helpful pattern. Here are scientific examples:

"As the ILP 11-5 activities evolve with time, new contributors and proposals will be initiated."
"During the one week-long workshop 11 participants from 6 different countries were exposed to direct field experience and evening lectures under the guidance of 8 instructors."

I would drop the unnecessary word *"one"* in the second example; it is already clear. It would also be more energetic to use an active verb instead of the passive *"were exposed to"* phrase. Perhaps "representatives … *participated in…"*.

Of course the natural order of time does not always mean A caused B by preceding it, but it gives the reader a memorable narrative frame.
However, remember: always be clear in distinguishing between cause and mere precedence in time! That is the layman's mistake and superstition, not a scientist's stance.

Sometimes of course writers give their information a double frame, say cause and chronology. Here is an untouched example:

"For the above reasons, at the time of the earthquake, we suspect there may have been a delta associated with the Fortore River and that the shoreline was probably much further out."

This is a very complicated sentence which is trying hard to help the reader by giving cause and chronology first. Its first four words do two things:

1. ably connect back to and summarize preceding sentences
2. and give causal/time frames

But this example moves back and forth between the past and present, perhaps confusing the reader.

It would be better to avoid this alternation by grouping all the present parts together (the now's) and all the past parts together (the then's) with separation between. The new version would be:

"For the above reasons, we suspect (in the now) *there may have been at the time of the earthquake a delta associated with the Fortore River so that the shoreline was much further out"* (all the then's grouped together).

This green version gives the reader clearer signposts to cause and time through placement. It also better explains the relation between delta and shoreline.

Strategic placement works! It makes your scientific thinking clearer, memorable, and powerful.

Here is a harder example of double frames - both cause and time are given to orient the reader. That is good! The original reads:

"In the gouge cores, we believe we have evidence for 3 tsunamis that inundated Lesina Lake, and 3 tsunamis that inundated the town of Siponto, based on field observations and on the constraints given by radiocarbon dating of selected samples."

Again this is a complicated sentence and unfortunately too long at 40 words. It is like the preceding example in moving back and forth between past and present times and could be more powerful in framing its information. We are not quite sure from the placement if the evidence is for where something happened or what happened. Are the samples really different from the gouge cores and is the carbon dating the only constraint as the structure says? A naïve reader (say a geophysicist!) might also wonder if we were talking about 6 tsunami altogether.

Consider this series of revisions:

A. "Based on constraints given by field observations and radiocarbon-dated samples, the evidence of gouge cores shows that three tsunami inundated Lesina Lake and three flooded the town of Siponto."

Would that be more correct geologically? Or should it be and the evidence of gouge cores? Again the reader could assume that the carbon dating of selected samples is different from the gouge cores with the versions we have so far. Hold that question while we look at what is good about this stage of revising.
The new green version has 30 words if we count the hyphenated one as 2 (10 fewer is better because easier to

remember!) yet maintains the good "why" format of the original and uses the active verb *"shows"* for greater energy. It now keeps the present and past clearly separate. Nor does it bury the main idea in a dependent clause after *"we believe…"*. It also keeps *"evidence"* and *"gouge cores"* closer together on the page.

However, it is more sophisticated in four more ways still:

1. Using the correct plural of *"tsunami"*.
2. Framing both constraints (observations and dating)
3. Leaving out the second *"tsunami"*. The close repetition of "three" makes the sense very clear and readers will be flattered by your trust of their intelligence and memory.
4. Varying diction for greater interest, not two *"inundated's"* in a row.

Let's keep fine tuning:

B. "The evidence of gouge cores shows that three tsunami inundated Lesina Lake and three others flooded the town of Siponto. Constraints given by field observations and radiocarbon dating of selected samples also support this thesis. (or "interpretation")"

This green version in *two shorter sentences (total of 35 words)* has different advantages from the one directly above.

Sentence 1: Like A. above, it preserves the causal frame of the original but makes the improvement of putting the logical pairs *"evidence"* and *"gouge cores"* closer together (only one word apart). Unlike A, it does so in a tighter and therefore stronger sentence of 20 words, not 30. As with A only 5 short words separate "evidence" from its logical mate: "tsunami." But here we go right to that connection: in A, we needed to digest 11 words before that part of the thought. (Those words are now separate in sentence two.) It all depends on how big a thought bite you choose to offer the reader. Dividing an idea into two gives the reader time to digest. (Think of the period as a coffee break.)
This new revision also clarifies for the less expert reader unfamiliar with Italian geography and geological history that there were 6 tsunami by saying *"other."* (If that is true?)

Sentence 2: These 15 words have more power when set apart, not tacked on to a long preceding unit as in the original. But what did I try to preserve from that untouched example?
I wanted to keep the good order of the original case: *"based on field…"* to preserve its causal frame, showing in its form how we deduce the interpretation after the observations and dating. (After all that's how cause and time work in the scientific method.)
I also wanted to preserve the idea of *"we believe"* in the words *"thesis"* or *"interpretation."*

But Version B has drawbacks too.

Unlike A, it alternates between the present and past in a somewhat confusing way.

And neither A nor B solves the unintended effect of gouge cores looking different from the carbon-dated samples. (As written, both revisions and the original imply 3 pieces of evidence: cores, field observations, and dated selected samples).

So now that we are really tired of this sentence, our final fix might be:

C. "Based on our field observations and gouge cores, selectively carbon-dated, we find that three tsunami inundated Lake Lesina and three others flooded the town of Siponto."

Whichever revision you choose, always remember the overall rule:

place your units for maximum logical flow and clarity, using the frames of cause and chronology.

Skill Three: Letting transitions and connections guide your placement of ideas makes that dangerous space between closing punctuation and the next capital much safer!
That white space between sentences is where we often lose our readers. Through strategic placement or framing, we can bridge that gap.

Here is an example.

"A team of three surveyors was formed to record the effects of the tsunami both in the near field, the Eolie Archipelago and in the far field along the coast of Campania, Calabria and northern Sicilia regions. Visible material effects of the shear wave could be observed only in Stromboli …"

The danger area here is between the period after *"regions"* and the capital *"V."* In other words, the writer had trouble getting from *"the surveyors"* to *"the visible material effects"* they observed. Too many words intervene between that naturally connected pair.

How to fix? Let placement set up the context for you so that it leads naturally into the transition. Start with *"why"* and *"where."*:

"To record the tsunami's effects in the nearby Eolie Archipelago and along the coast of Campania, Calabria, and northern Sicily, a team of field surveyors was formed. They observed material effects of the sea wave only in Stromboli…"

or:

"They saw the sea wave at work only in…"

This would be better because it:

Gives the causal frame first
Gives the spatial setting sooner (*"nearby…"* is only the 8th word here)
Puts the agent (surveyors) only two words away from what they do: observe. The transition works better because the writer has thought ahead to what she wants connected logically and placed those thoughts together on the page. So choose as your last word one that can serve as a springboard to the next thought.

I draw your attention in the revision to the tighter format (fewer words and key words close together) and the more commonly used English place name (Sicily).

Here's another, longer example about geological space "out there" and space within the paper: a transition across two of its sections.

"In general, the alluvial complex does not experience strong erosion, with the exception for the alluvial fan near Mocaiana, the northern part of which has been eroded by the Assino River (Fig.2). Moreover, the alluvial fan, just north of Gubbio (Fig. 5, cross section 13; Fig.8), acts as local divide for the drainage basin (see prf. 3.2 Drainage network). 47 words without counting words for figure notations

3.2.-Drainage network
The Gubbio drainage basin is formed by two secondary hydrographic networks, connected with the Assino and Chiascio rivers."
18 words not counting the figure notations.

This version can be molded into a more fluent (no pun of course) passage using better spatial and transitional frames. Consider this:
"Generally, the alluvial complex experiences no strong erosion, except for the ***one*** *fan near Mocaiana whose northern part has*

been eroded by the Assino River. Just north of Gubbio, ***another*** *fan divides the drainage basin…* 35 words here

3.2.-Drainage network
Two secondary hydrographic networks connected with the Assino and Chiascio Rivers form ***this latter*** *basin."* 15 words here and they now avoid the close and therefore boring repetition of "basin" that had occurred across the section division in the original.

Or would it be clearer to say:

"form the ***entire*** *Gubbio drainage basin".* (If possible, I would prefer to drop the word "Gubbio" to avoid overusing it.)

As a non-scientist, I can't tell how many basins we've got going here, but the original seems to indicate the second choice: only one basin. Either revision would tighten up the original by getting key words closer together and clearly specifying in situ the number and extent of the fans (the original paragraph had said 4 fans but too far away from the specific references coming later). A clear spatial map with no ambiguity is essential.

I have tried showing in bold the words that clarify by showing spatial connections in the real world and in the paper.

Skill Four: Moving from small to large and vice versa

When cause and effect or present and past are scrambled in careless writing, the reader will be unnecessarily confused, as we have seen here and often see in our early drafts. Framing our thoughts through revision makes all the difference.
This last skill is again one of control: choosing the frame for your ideas, whether inductive or deductive or both. Here is an example of such competence from science journalism by Kenneth Chang. His article appeared in The New York Times on December 17, 2002 and is titled "Nature's Secret to Building for Strength." Although not technical like your writing, it is very useful as a clear and clean expository (explanatory) model. In later lectures I will use it again to illustrate writing skills.

To ease us in, Chang starts with a general and indeed proverbial thought: *"bend, don't break."* Then he illustrates it with specific examples which move from small scale soap film and glass fibers to willow trees. Paragraph two ends on the larger scale of *"powerful gusts"* which link to *"flags"* flapping in the same *"wind"* in the next paragraph. Wind is the continuous link between plants on the small scale of leaves or the larger scale of tree sections and underwater kelp forests in the wind of the sea: waves. Each paragraph moves from a small object/organism to a larger object or force.

These examples lead up to an inductive generalization by Vogel, a professor mentioned earlier:

" 'Natural structures tend to be more flexible than the stuff we build,' Dr. Vogel said. 'We build to a criterion of stiffness. Nature tends to build to a criterion of strength. It usually takes less material.' "

The next line moves us back from the large/general/inductive to the specific again: individual experiments. From those smaller examples we move back to find the general "equations that underlie nature's engineering." In other words, Chang moves the reader competently between:

deductive thinking:

- *what small things can fit into or be deduced from this larger given?*

and inductive thinking:

- *how do particulars add up to a new generalization?*

Nature's Secret to Building for Strength: Flexibility

By Kenneth Chang

Bend, don't break

With an experiment of soap film and a short glass fiber, mathematicians at New York University have worked out some underlying principles of how something like a willow tree withstands powerful gusts.

The same researchers showed two years ago why flags flap in the wind.

Years ago, biologists started observing how plants had adapted to the flow of wind and waves around them. Some, like Dr. Steven Vogel, a professor of biology at Duke University, put sections of trees in wind tunnels and videotaped how leaves rolled up into tight streamlined cones when buffeted by high winds.

Other biologists like Dr. Mimi A. R. Koehl, a professor of integrative biology at the University of California at Berkeley, have studied how the undulating motion of underwater kelp forests rolls with the motion of waves.

"Natural structures tend to be more flexible than the stuff we build," Dr. Vogel said. "We build to a criterion of stiffness. Nature tends to build to a criterion of strength. It usually takes less material.".

Those observations allowed scientists to describe in general terms what was occurring, but not the equations that underlie nature's engineering.

The N.Y.U. researchers - Dr. Jun Zhang, a professor of mathematics and physics; Dr. Michael Shelley, a professor of mathematics; and Silas Alben, a graduate student - built an experiment to study a much simplified version of the dynamics.

"Then you have an example where you can say precisely what is going on", Dr. Shelley said.

The experiment, a rarity for mathematicians, consisted of a tank that squirted a steady downward stream of soapy water along two vertical threads. Drawing the threads apart produced a soapy film that slid down between the threads at adjustable speeds, from 1.5 feet a second to 10 feet a second.

In experiments in 2000, the researchers placed a silk thread in the flow to simulate the motion of a flag. Up to that point, most scientists had thought - as Lord Rayleigh had proposed in 1879 - that flapping was inevitable, caused by quick changes in the speed of air flowing on either side of the flag.

The N.Y.U. team showed that at low speeds the silk thread remained stretched out straight. At quicker speeds, the thread flapped back and forth in a steady pattern.

Intentionally framing your thoughts this way will give your writing an hour-glass shape that interests readers by changing. In fact you could describe the typical format of a scientific paper that way: the abstract presents the general conclusion; the body itself gives the details which generate or support it; and the conclusion again "goes general." The secret is to group each kind together and move between them with control, not haphazardly.

Conclusions**:** Generally, readers feel secure when they feel the writer is guiding them with assurance and competence. The four framing skills we have looked at here will create that feeling. Please work on them!

Homework practice:

Take 4 sets of any three sentences from a paper you are writing or reading in English and practice each skill from today. Discuss your before and after results with a colleague for feedback ("peer editing").

Lecture 3

How Long is Long Enough? Varying Length to Avoid Information Fatigue and Boredom

Last week we had a very wet talk full of tsunami, inundated lakes and towns, rivers and delta formations. I will pick up on that now to move us into today's subject: controlling and varying the flow of our thoughts. Think of the information you wish to convey as the Tiber River and today's skills as embankments to contain and channel it. If we master these skills, your thoughts will not overflow; readers will remember your thesis because they will not be overwhelmed by it. So how do we build these banks, dams, and weirs for words?

Skill One: Controlling the length of sentences by counting the number of words per sentence and weeding/trimming prepositions

Skill Two: Controlling word length and type relative to sentence length so that long sentences don't also carry long, abstract nouns

Skill Three: Alternating sentence lengths for good rhythm to refresh the reader's mind and ear.

All of us have been to lectures delivered at length in a monotone with no pauses or variety from audio-visual aids. We've all been subjected to boring, over detailed endless stories narrated in a rush of long sentences with no apparent breath. Our writing should not mimic those experiences, for no reader will remember a masochistic ordeal fondly.

Skill one will help us avoid the drone of impossibly long sentences that confuse length with importance. How can we detect such sentences in our first drafts, often worked over with great anguish? We become attached to them because we have invested so much in them. But good writers must focus on the desired product, not the process! Be ruthless in revising. Shorter is often better. Shorter units are easier to assimilate and keep key concepts closer together as well.

To illustrate skill one, I will use several examples including a brochure that an institute scientist and I revised. We brainstormed the science needed and the best way to say it. Bouncing ideas off one another in this way works wonders.

Here are steps to follow in your revising:

First, read each sentence out loud. As I've mentioned before, each should be read comfortably in one breath. The breath test helps you find the right length of thought that readers can assimilate. Think of that breath as a dam in our metaphorical Tiber of ideas.
Mark on your paper copy or terminal where you run out of breath and actually count the number of words wherever that happens. Measurement is very instructive! Try breaking the overly long sentence into two. Look especially for natural hinges like the conjunctions: and, but, for, because. Other good breaking points occur where subordinate clauses (units that cannot stand alone but have subject and verb as in "which completely rupture the fault) meet main units.

Here is a good example to break apart. Although it follows a good "*if-then*" format, this single sentence carries so much information that the reader weakens. I have tracked some changes to show how we might shorten this flood of words.

"*In summary, (1) the paleoseismological vertical throws observed at all three sites are generally considered minimums and*

exceeded a few tens of cm to reach up more than 1 m (inset in fig. 10); (2) a strong similarity of throw values exists between paleoseismological and 1894 reports; (3) at least ATL-PEN ruptured two sections of the Atalanti fault; (4) according to Wells and Coppersmith (1994), the observed paleoseismological vertical throws are compatible with surface rupture length ranging between ca. 28 and 32 km (from average displacement vs. surface fault length and maximum displacement vs. surface fault length for normal faults). ***We conclude*** *that the ancestors of the 1894 likely had a magnitude similar to that of the 27 April 1894 event (ca. M 6.8 according to…) probably producing the complete rupture of the Atalanti fault."* (Roughly 128 words)

Note where the main subject-verb *"we conclude"* is placed, following several subordinate structures. That is where we can give the tired reader relief. Start a new sentence: *"Thus, we conclude that the ancestors of the 27 April 1894 event probably had a similar magnitude (ca. M 6,8 according to…) which might have completely broken the fault."*. Or use a bullet format for the four points and then start a new sentence at *"We conclude"* for which I indicated some possible revisions above to increase impact.

It is very important to set off findings by themselves in a sentence which contrasts with the preceding. That will help the reader remember your results.

Another place to break overly long sentences is between compound verb phrases. If we look at the Relief brochure, we read 48 words in one sentence under paragraph 3, *"A Natural laboratory."* The sentence uses *"to improve observational and theoretical methodologies…"* and *"to establish models of crustal processes..."* in parallel or tandem. It is a good verb duet but too long.

"A natural laboratory

The Izmit-Duzce earthquakes of 17 August and 12 November 1999 (Mw 7.4, Mw 7.1) offer an invaluable natural laboratory to improve observational and theoretical methodologies for seismic-hazard assessment, and to establish models of crustal processes, fault mechanics and site behaviour that can be applied more widely in the European domain."

I reorder the sentence for stronger impact and divide its compound verb phrase up, making two new sentences of 25 and 23 words: each tells what the "laboratory" can be used for. The total count is the same but now in more digestible bites. The river of information stays within its banks.

*"**A natural laboratory***

The Izmit-Duzce earthquakes of 17 August and 12 November 1999 (Mw 7.4, Mw 7.1) offer a natural seismic laboratory for improving observational and theoretical methods of assessing hazard. This laboratory will help us establish models of crustal processes, fault mechanics and site behaviour that can be applied more widely to Europe."

Note the ease of starting up the second sentence by repeating the key word *"laboratory."*

These next overly long examples and their corrections come from the same brainstorming session on the Relief brochure. Let's look at the first three original sentences preceding "A Natural Laboratory." They have the following word counts: 36, 29, and 30, if we count hyphenated words as two. Given the difficulty and abstraction of the concepts contained in those accumulated 95 words, the sentences are just too long (especially before the Laboratory paragraph). The river of information overflows.

We begin with the title:

*"**A new earthquake hazard approach for Europe***

The 1999 seismic sequence of the North Anatolian Fault Zone raised a number of critical questions about our perceived understanding of the relationships between faults and earthquakes and our ability for significantly reducing the seismic hazard. Modern approaches including paleoseismology, seismic source and strong-motion studies can resolve a number of key fault parameters needed to test and refine fault-behaviour and seismic-hazard models. The integration of innovative research tools with traditional methods allows for both characterisation of earthquake faulting parameters and development of technolo-

gies and models to observe and analyse earthquake-related phenomena."

Here is the revised text:

*"**A new approach to assessing earthquake hazard in Europe***

The 1999 seismic sequence of the North Anatolian Fault Zone raised new critical questions about the relationship between faults and earthquakes and our ability to significantly reduce seismic hazard.
To address these questions, RELIEF will apply modern paleoseismology, seismic source and strong-motion approaches for resolving key fault parameters needed in testing and refining fault-behaviour and seismic-hazard models. By integrating innovative research tools with traditional methods, the project will characterise earthquake faulting parameters and develop technologies and models to observe and analyse earthquake-related phenomena."

Why these changes? I will go line by line to explain them and throw in some general comments beyond our skills for today (some review skills and some coming attractions).

The revised title puts *"hazards"* closer to *"Europe"* to stress that urgency; after all that is the reason for the Relief project. It also features by putting first what is special about the proposed plan: its *"new approach."* The original title was also unintentionally gloomy in its first four words, as if there were a new seismic hazard facing Europe. It is always clumsy and sometimes confusing to string 3 or more nouns together. Avoid if possible.
The scientist wanted "assessment" as a key word in the revised title, so I put it in the most powerful form: verbal. Adding Relief and a colon before the title would be better yet for memorability. The short:long or long:short appositive / restatement format is excellent.

The original first sentence of 36 words uses a good active verb: *"raised."* However, 10 words come after it and include 3 prepositional phrases, always "flabby." The phrase *"critical questions"* includes the concept of thinking/wondering/understanding and is thus redundant with "our perceived understanding." We don't need both *"critical questions"* and *"understanding,"* especially since we want to get to the key concept quickly: what is the tie between faults, quakes, and reducing their damage?

The new sentence has 29 words, 7 fewer. It's still a little long, however. It improves upon the original in halving the number of prepositional phrases from:

Of the… Zone
Of critical questions
About our… understanding
Of the relationships
Between… earthquakes
For reducing… hazard. ("ability for" is non idiomatic, incorrect)

To only three:

Of the… Zone
About the relationship
Between… earthquakes

Prepositional phrases make for padding: all fat and no bone. Too many words. The infinitive *"to reduce"* is much stronger than *"for reducing."*
I left out the definite article *"the"* before seismic hazard because it is tighter and we are talking about seismic hazard in general. If you can add *"in general,"* it is fine to omit "the."

The second paragraph of the original has two sentences of 29 and 30 words, respectively, which loosely follow one of 36 words in paragraph one. That total of 95 is rather high, telling us that the thought units are heavy. It is hard to ponder the ponderous! So remember to think about the cluster of sentences around any one for its accu-

mulated impact. Think of sentence clusters as an earthquake swarm if that would help. Each sentence length adds up and affects the others.

Now let's look at our brainstormed version of 31 and 27 words, respectively, following one of 29 words. This revision adds up to 87, 8 fewer than the original. That means the reader does less work to process thoughts and can remember their connection better because they are tight on the page.

What also matters beyond the word number is

where those words are for emphasis,
what part of speech they represent,
and how they link up with surrounding thought.

Try to keep all those parameters in mind as we go on separating them artificially to understand better.

Our brainstormed version more closely ties the second unit to the first paragraph by framing (remember the last lecture?).

Sentence one of this second paragraph foregrounds Why and Relief: Relief will apply new approaches to address these questions (*"Questions"* is the 14th word of sentence one and is used again to link paragraphs). Sentence two in the revised version is also given better context now: We first explained how the project will *"observe and analyse…phenomena": "By integrating innovative research tools with traditional methods…"*

In the original version, paragraph 2 sentence 1, please note the active and short verbs *"to test and refine."* I would have loved to keep them but decided to emphasize process and parallel structure in the verbals: *"resolving, testing, refining, and integrating."* Keeping them parallel in form links them together in the reader's mind as the process which will then yield: *"faulting parameters and technologies and models…"*

Now how did I get the original sentence of 30 words down to 27 and still add a causal frame for clarity? As we saw above, one important tool is to reduce prepositional phrases from 5:

Of innovative… tools
With traditional methods
For both characterization
Of earthquake… parameters
Of technologies and models

to only two:

By integrating
With traditional methods

How can we do that in practice? Answering that question leads us to skill two.

Skill two means monitoring word length and type to control the overall length and impact of sentences.

A first step is to underline long words in your target sentences and see how many there are in a row. Usually such words are Latin or Greek in derivation and abstract in meaning. They represent concepts difficult to understand. Sometimes we need those technical terms as in sentence three's "parameters." But other words of length and abstraction may be converted to verbs or verbal forms to add vitality and get rid of prepositions.

Here's what I mean. Find below the main subject and verb phrase of unrevised sentence three:

"The integration… (subject).
"allows for both characterization of earthquake faulting parameters and the development of technologies…" (main verb phrase).

The verb phrase *"allows for"* is better than a mere state of being but is still somewhat wimpy/weak. Moreover, the key concepts are buried as nouns in prepositional phrases. I convert them to verbs and eliminate wasted words:

"By integrating…, the project will characterize earthquake faulting parameters and develop technologies…"

The result is a more forceful and memorable claim in 3 fewer and shorter words. Shorter is very important in offsetting scientifically necessary long terms like *"technologies."*

Remember to seek balance in long and short words within a sentence. Include short words within a long sentence for relief.

You will find that the long words are usually nouns accompanying prepositions. Weed some long nouns out by doing a search (with your word processor) for the following:

in, by, for, at, between, inside, under, next to, to

Don't confuse the dangerous preposition *"to"* linking nouns with the infinitive *"to sing, to dance, to observe and to analyse"*. Unlike space-taking prepositions, infinitives are "good guys" as sources of energy.

Now let's look at **Skill Three**: varying sentence lengths for the variety that keeps readers interested and awake. This skill is one of context, going beyond individual sentences to their interaction.

We can see the positive value of varying lengths in our sample brochure as the eye is comforted by short titles and shorter phrases in bullet format. These alternate with longer sentences in paragraphs. Such variety refreshes the eye and mind to help us remember the information. Please look at the complete brochure later at the end of this lecture.

Here's a text sample from a very convenient point source, my husband and tutee Dave. I took the beginning and 2 final paragraphs from an abstract he just wrote. Indicated within are the word counts. Please note their variety to keep the reader alert. Very important is the short first sentence since openers are key. They will be memorable or catchy if short enough for readers to retain. Short is user friendly.
Also note the refreshing use of questions for a change from declarative sentences. Since such interrogative sentences may express the unknown, doubt, or skepticism, they work well at the beginning of papers and/or at the end as signposts for uncertainty or future research.

*"**Earthquake Prediction and Forecasting***

Predicting earthquakes is like predicting car crashes. (7) We can forecast their yearly rate and the trouble spots well, but we cannot predict individual events before it is too late. (22) Even defining earthquake prediction is challenging, because earthquakes are so different, both earthquakes and faults have fractal properties, and a good definition must deal with uncertainty. (26)
…
…
Modern studies show that earthquakes cluster in space and time, and earthquake probability spikes following a previous event. (18) Aftershocks illustrate this clustering, but later earthquakes may surpass earlier ones.(11) Specific models help reveal the physics and allow intelligent disaster response. (11) However, the clustering is too weak to justify the term "earthquake prediction", and the first large quake in a cluster usually causes the most damage. (25) Modeling stresses from past earthquakes may improve the odds of prediction, but this approach has not yet been validated prospectively. (20) Stresses inherit fractal properties, complicating the task of estimating the stress available for causing earthquakes. (15)
Where are we on the road to prediction? (8) Will a few bumps divert us? (6) How long is this road? (5) Does it even go there?

(5) My personal map shows, close by, deeper understanding, better forecasting and statistical validation. (13) However, prediction in the popular sense (individual events, high probability, and consistent success) lies off the map. (17)"

Thank you Dave for your sample, your computer help, and your suggestions on Microsoft word editing at the end of this lecture.

Here is a final review of today's skills:

1. Shorten overly long sentences by

Doing the breath test and counting words
Breaking at natural hinges
Using strong active verbs for concision and energy
Limiting prepositional phrases

2. Vary word and sentence lengths just as you give individual thought units the right length. Both strategies will make your ideas more digestible and memorable.

Next I will discuss punctuation as another tool for controlling information flow. And a few more tricks!

Closing: some of you may have thought that my water bottle was the prop for today's workshop. After all we started with the Tiber as a metaphor for flow of ideas. But I have saved till last my real prop: A ruler.

I'm not going to rap knuckles for writing errors, like the bullying language teachers of caricature. Instead the ruler reminds us all to measure length: both word and sentence. Improvements in your writing and speaking will follow immediately!

The Brochure: original version

*"**A new earthquake hazard approach for Europe***

The 1999 seismic sequence of the North Anatolian Fault Zone raised a number of critical questions about our perceived understanding of the relationships between faults and earthquakes and our ability for significantly reducing the seismic hazard. Modern approaches including paleoseismology, seismic source and strong-motion studies can resolve a number of key fault parameters needed to test and refine fault-behaviour and seismic-hazard models The integration of innovative research tools with traditional methods allows for both characterisation of earthquake faulting parameters and development of technologies and models to observe and analyse earthquake-related phenomena.

A natural laboratory

The Izmit-Duzce earthquakes of 17 August and 12 November 1999 (Mw 7.4, Mw 7.1) offers an invaluable natural laboratory to improve observational and theoretical methodologies for seismic-hazard assessment, and to establish models of crustal processes, fault mechanics and site behaviour that can be applied more widely in the European domain.

Main issues

(1) *Understand how faults produce earthquakes and how permanent deformation is recorded at the surface;*
(2) *Test fault segmentation and characteristic earthquake models as viable scientific concepts;*
(3) *Estimate the impact of past earthquakes in the light of the recent events and model the likely crustal deformation predicted for future earthquakes;*
(4) *Develop new methodologies and scenarios for seismic-hazard prevention in Europe;*
(5) *Integrate studies of Active Faulting and Paleoseismology, Physics of the Seismic Source, Engineering Seismology and Seismic Hazard Modelling within the European frame.*

lecture 3

Improving text with word processors

David D. Jackson

1. Run the "spell checker", set for spelling only. It won't do everything, but it will catch many problems.

2. Set your spell checker to include grammar and style, and run it again on your document. If you use Microsoft Word, click **Tools**, **Options**, and **Spelling and Grammar** to get a dialog box. (Here, I use blue text to show what you see on the screen in Microsoft Word). In the dialog box, under **Writing Style**, choose **Spelling and Grammar**. Click **Settings** and check all the boxes. Now run the spell checker again. You will surely see many problems indicated in green text. It will catch most instances of lack of agreement between subject and verb, dangling modifiers, and overlong sentences. These should be fixed as you go along. Word will also flag every sentence in which you have used the passive voice. You won't need to fix every instance, but try to reword most sentences using the active voice. You may also get a lot of reminders about use of the first person: I, we, me, us, etc.

   You may want to change many of these to share credit or blame with others, or alternatively ignore the messages if it is appropriate to use the first person for your document.

   Grammar checking should find long sentences, but you may want to look at sentence length yourself. In Word, click **Edit** and **Find**. In the dialog box, enter "." in the "**Find what:**" box, and check "**Highlight all items found in**: Main Document".

3. Search for words or phrases (using **Edit**, **Find**, **Highlight** as above) that you use too often, and replace them by synonyms, or shortened versions as appropriate. You may spot such words and phrases by examining the Abstract, Introduction, or Conclusions of your document. For me, "statistical testing," "probabilistic seismic hazard," and "probability density" show up too often. I try to substitute "validation," plain old "hazard," and "pdf" (after defining as "probability density function" just once), use other synonyms, or leave out the phrases altogether if possible. Words like "occurred" may often be omitted entirely if you are writing about earthquakes or other frequent phenomena.

4. Search for words or phrases that indicate complicated structure, dependent clauses, or prepositional phrases. Here is a list:

   which, that, who, of, in, for, between, by, next, inside, under,over

   If you have a lot of phrases involving these words, try to reword some sentences to avoid use. Also, read aloud those sentences containing these words to see if they sound ok to you.

5. Search for "may," "might," "should," and "suggest." These are weak words, especially when used in combination. Replace "might suggest" with "suggest," because "suggest" is already pretty tentative. Look for "relate" and "associate." Use stronger verbs, like "cause" or "result from" if appropriate.

Innovative paleoseismological methods

- *Construction of numerical 2D – 3D trench data*
- *Study of multi-proxy indicators of past earthquakes through innovative paleoenvironmental research (lake sediment sequences, tsunami inundation and coastal wetlands)*
- *First application of dendro-seismology in Europe*
- *Rigorous dating control through independent but complementary geochronological techniques.*

Development of new models

- *Mechanical models of fault behaviour and interaction*
- *Mechanical models of fault rupture and of earthquake clustering*
- *Probability density functions and earthquake recurrence models*
- *Physical models for crustal stress transfer*
- *New models of site-effects for the near field*
- *Critical evaluation of previous seismic hazard assessment and new models of earthquake hazards"*

The Brochure: revised version

"***A new approach to assessing earthquake hazard in Europe***

The 1999 seismic sequence of the North Anatolian Fault Zone raised new critical questions about the relationship between faults and earthquakes and our ability to significantly reduce seismic hazard.
To address these questions, RELIEF will apply modern paleoseismology, seismic source and strong-motion approaches for resolving key fault parameters needed in testing and refining fault-behaviour and seismic-hazard models. By integrating innovative research tools with traditional methods, the project will characterise earthquake faulting parameters and develop technologies and models to observe and analyse earthquake-related phenomena.

A natural laboratory

The Izmit-Duzce earthquakes of 17 August and 12 November 1999 (Mw 7.4, Mw 7.1) offer a natural seismic laboratory for improving observational and theoretical methods of assessing hazard. This laboratory will help us establish models of crustal processes, fault mechanics and site behavior that can be applied more widely to Europe.

Main goals

- *Understand how faults produce earthquakes and how permanent deformation shapes the surface;*
- *Test fault segmentation and characteristic earthquake models;*
- *Estimate the impact of past earthquakes in light of the 1999 events and model crustal deformation predicted for future earthquakes;*
- *Develop new methods and scenarios to reduce seismic-hazard in Europe;*
- *Integrate within a European frame studies of Active Faulting and Paleoseismology, Physics of the Seismic Source, Engineering Seismology and Seismic Hazard Modelling.*

Innovative paleoseismology

- *Construction of numerical 2D – 3D trench data;*
- *Study of multi-proxy indicators for past earthquakes through new paleoenvironmental research;*
- *First application of dendro-seismology in Europe;*
- *Rigorous dating control through independent but complementary geochronology.*

Development of new

- *Mechanical models of fault behavior and interaction;*
- *Mechanical models of fault rupture and earthquake clustering;*
- *Probability density functions and earthquake recurrence models;*
- *Physical models for crustal stress transfer;*
- *Models of site-effects for the near field;*
- *Models of earthquake hazards."*

Lecture 4

Controlling and Varying the Flow of Ideas

Here I'd like you to consider an ancient Roman skill: building aqueducts to deliver water in the right amounts to the right places at the right times. Think of your writing and rewriting as a similar form of engineering; words, like water, must flow properly and are as necessary to sustaining science as water is to life. So here I'll suggest some more "tools" for that engineering feat. The previous lecture addressed the right amount of information flow. Here, we'll work on controlling and varying the pace/rate and destination of our words through correct punctuation, ellipsis, and variable word order.

Tool One: Punctuation or rest stops. A great comedian makes a joke work by pausing at the right junctures. Unfortunately, writers must make their exposition work on the silent page. How do we achieve meaning and impact there? One way is through punctuation. Such symbols are pauses or rest stops of different lengths like musical rests. In writing as in music, the longer the pause, the stronger can be its effect. In order of strongest to weakest, see below:

1. Ending notation like **. ? !** to show the end of a thought unit. However, the ! is rarely if ever appropriate in scientific writing. Neither is the – except to indicate a range meaning "to" as in "each 660-1120 years" or "0.5-1.6 mm."

2. **;** The semi-colon separates complete sentences from each other that are grouped but lack the conjunctions "and, but, for, or." Semicolons also should be used to separate units in a list that contain internal commas so the reader knows where each unit ends.

3. **:** The colon is used to introduce a list or series after such words as "Consider the following." Avoid placing the colon between the verb and its direct object(s) or other predicate. A very important second use of the colon is to set off an explanation or restatement. Then it works as an equal sign: A=B, as in "Relief: A new approach to assessing seismic hazard in Europe." A colon does not usually separate complete sentences.

4. ( ) Parentheses are for enclosing explanatory matter or material less important than the sentence proper.

   "Near heavily populated and industrial areas, earthquakes provoke numerous human and material losses (casualties are in parentheses): Kwanto, Japan 1923 (200,000); Tangshan, China 1976 (500,000)…"

   "As the active source we consider a linear cable supplied by an alternating current (see Appendix)."

   "Let us take the geophysical anomaly and medium to be conductive (the displacement currents are neglected) and non-magnetic (equation)."

5. **,** The dangerous but essential comma is often overused and occasionally underused because it is so tricky. It represents a quick breath in the sense of a sentence. Below follow examples of its correct and incorrect uses.

   "Average slip per event and vertical slip rates are of ca.60 cm and 0.5-1.6 mm/yr., respectively". Always set off the word "*respectively*" with a preceding comma. (Please be advised that some journals use a period after cm. km. etc.)

   "Conversely, these results may shed light on seismogenic potential…". Use a comma to set of logical turns like: "*On the one hand*", "*on the other hand*", "*However.*" It is not needed after short logical signposts like "but" or "yet."

"For the first time a major country, Germany, will adopt as a basis for its national building code, a map produced in a multinational program".

The green section shows the paired commas doing their proper job of setting off an "appositive" or "explanation". The word "Germany" (place " " around words used as words and definitions) explains specifically which major country.

The red section shows a comma-happy mistake. Never insert a break between the main verb *("will adopt")* and its direct object *("a map")* if it can be avoided. Such breaks confuse the syntax. Remember that direct objects explain what (kicked the ball) or who (kicked her) receives the verb's action (kicking). For clarity, keep the direct object as close to the verb as possible: *"I explained it to her."* In an "analytic" language of placement like English, the indirect object (*"her"*) is always second so the reader knows which is which.

I think the extra comma separating the verb phrase happened because the writer meant to say: *"For the first time, a major country, Germany, will adopt, as basis for its national building code, a map produced in a multinational program."*

Now that comma after "code" is technically correct as one of a pair setting off the non-defining, non-essential phrase *"as basis for its national building code."* But is that message from punctuation what the writers meant the reader to deduce? The result is also very choppy with 5 commas in a 24 word sentence. The sentence stutters badly. If we want flow, try this:

"Germany is the first major country to adopt a map produced in a multinational program as the basis for its national building code." (23 words)

"First among major countries to do so, Germany will adopt for its national building code a map that was produced multinationally."

Both rewrites would work but now say that each part is defining or essential to the meaning. Nothing is demoted by paired commas. Placement conveys that meaning without any commas in example 1. In example 2 we now have only 1 comma properly used to set off long introductory material (here an adjective frame) from the main subject and verb: *"Germany will adopt."*

Note that if we place our ideas in a sense-related order, we need few marks of punctuation to help direct the reader. Placement eliminates the need for much punctuation. If you're not sure how to punctuate, try reordering first; keeping the key ideas closer together and the modifiers by the modified will solve many ambiguities. Shortening your sentences will also help.

Commas, like all punctuation, are there to channel information so that it comes at the right level of importance and right speed. Too many are as bad as blockages in our metaphoric aqueduct. Too few will make the aqueduct overflow.

The general rule is to place no comma between grammatically linked parts. Don't cut up the sense. Here for example are incorrectly separated subjects and verbs:

"The Central Apennine Geodetic Network (CA-GeoNet), consists of 130 stations…" (The parentheses themselves need no additional comma.)

"The mainly E-W deployment of INGR, VVLO AND ROSE permanent station with AQUI (ASI permanent station), allowing an high precision estimation of the current strain rate…"

Here's a fix for this troubled sentence:

"The mainly E-W deployment of INGR, VVLO and ROSE permanent stations with AQUI (ASI permanent station)

allows for highly precise estimates of the current strain rate…"
Now we have a tighter sentence whose independent verb *"allows"* (the original present participle *"allowing"* needed a helping verb) is not divided from its noun *"deployment."*

A subject with two parts linked by "and" also wants to be together. Try not to inject commas between those grammatical equals. The comma pair below is an unnecessary "fence".

"The marshy eastern end of Lesina Lake, and the low narrow sand spit that separates it from the sea, combine to create conditions favourable…" (favorable in American usage).

Here the subject pair "end" and "spit" are presented as equally important by the grammar; setting off the second subject inside commas as if it is non-essential contradicts this structure and the plural verb *"combine."*

I think the writer may have been confusing necessary internal commas with the incorrect external one before the verb *"combine"*. We do insert commas within a compound subject having three or more parts in a list, as in:

"Strong earthquakes, tsunami, and volcanic eruptions are extremely catastrophic."

Note that no comma separates the verb *"are"* from its trio of subjects.

Equally mistaken are "comma fences" between compound verbs in a sentence. Here is an example:

"This archeological estimate agrees with the radiocarbon ages reported above, and further constrains the timing…"

Like the example of *"end"* and *"spit"* above, the verb pair *"agrees with"* and *"constrains"* has equal importance. An intrusive comma interrupts their parallelism and logical flow. Perhaps the writer was thinking of the old rule to put a comma before conjunctions like *"and"* when they introduce a new main clause. Here, however, the conjunction links two verbs of the same main clause, not the second part of a compound sentence having its own new subject. If we add a mistaken comma after *"above"* in our example, we fight against the connection between the subject *"estimate"* and its second verb *"constrains."* That relationship is just as important as the first between *"estimate"* and *"agrees…"*

Nor do we want intrusive commas between adjectives modifying their nouns:

"The network extends from southern Umbria (Norcia area) to Abruzzo and southern Lazio (Sora area), regions and across the Central Apennine belt …"

The one noun "regions" nicely follows its modifiers Umbria, Abruzzo and Lazio and should not be separated from those grammatical partners.

So please remember this rule: punctuation should never pull against grammar/syntax. It is a tug of war that the reader will lose!

For general punctuation questions, I recommend Bill Bryson's *Troublesome Words*. And note that American practice, as here, keeps , and . within the ending quotation marks.

Tool Two: Ellipsis, or knowing what to leave out. Nothing wearies and sometimes insults a reader like repetition of the same phrases and individual words. Writers must know their audience to know how much can be tacitly understood. But if you are writing for a journal of specialists, you can assume they will know the context. If you have just referred to a 1915 event, you don't need to say again: *"The occurrence of such a large event …"*. The word *"event"* means *"that which has happened"* so unless there is a modifier like "hypothetical" or "presumed" you can leave out "the occurrence of."

Ellipsis is more sophisticated and brings key concepts closer together. For example we can tighten the following overly specific definition by leaving out:

"We refer to the events that deposited these disturbance layers as Events 1, 2, and 3 where Event 1 represents the most recent and Event 3 represents the oldest depositional event." (5 "events" and 2 "represents")

"We refer to the events depositing these disturbance layers as Events 1, 2, and 3 where 1 represents the most recent and 3 the oldest."

If that version seems ambiguous in mixing layers and events, consider:

"These disturbance layers were deposited by events we refer to as Events 1, 2, and 3 where 1 represents the most recent and 3 the oldest."

It is more elegant and flattering to the reader to let one word act more than once for nearby parallel constructions as the verb *"represents"* does above. Another example, this time a noun, follows:

"Using geochemical, geophysical, and geodetic data, we find…"

Below is a passage in which the preposition "of" can do double duty because it has double direct objects, "field" and "variation". The original reads:

"The behaviour of the geomagnetic field and of its secular variation is very complex and almost every attempt to characterise definitively their main features has proved unsuccessful."

A possible fix (17 words) would leave out the unnecessary second "of" to illuminate the grammar and also repair the mismatch between the singular subject *"behaviour"* and *"their."*

"The complex behaviour of the geomagnetic field and its secular variation makes characterising its main features difficult."
(Remember that *"of the geomagnetic field and its secular variation"* is only a prepositional phrase used as an adjective. It does not change the number of the subject *"behaviour"* so *"their features"* won't work). One tighter sentence works better.

A longer passage from an abstract will illustrate what can be left out because the subject is already clearly "on the table."

"Despite the great amount of studies on the processes that generate the geomagnetic field, some of its main aspects are not completely known yet. One of the consequences is the difficulty to predict, even for short time intervals, say of a few years, its apparently erratic temporal behaviour. Some recent studies suggest the possibility of a chaotic regime for the fluid core motions originating the field; if this were true, for short-time predictions a nonlinear forecasting approach would produce better results than any linear method. To test this statement, a nonlinear forecasting method is compared with other four linear forecasting techniques when applied to some geomagnetic field observations. The linear techniques range from a simple linear regression to more sophisticated procedures… Results show with a good statistical confidence that the nonlinear method is definitely the best way to predict the geomagnetic field one year ahead, supporting the initial idea of an underlying chaotic dynamics."

What is good about this clear passage? The authors try varying terms for interest, as in the synonyms *"approach," "method," "techniques,"* and *"way."* Similarly, they delay for variety where the subject comes in the first and last sentences (1 and 7 of the original).

But we attentive readers are told more than we need to know. The information moves too slowly because it becomes repetitive and over specific. Let's "massage" the excerpt a little:

"Despite many studies on how the geomagnetic field is generated, some of its main aspects are not well known. One consequence is the difficulty of predicting, even for intervals of a few years, its apparently erratic temporal behaviour. Some recent

work suggests a chaotic regime for the fluid core motions that cause (or initiate) the field. If this were true, a nonlinear forecasting approach would produce better short-term predictions than would any linear method. To test this connection, (or "to test for chaos"? - discuss) *some geomagnetic field observations are used to compare a nonlinear forecasting method with four linear techniques. These range from a simple linear regression to more sophisticated procedures…Our results show with good statistical confidence that the nonlinear method best predicts the geomagnetic field for one year, a finding that supports underlying chaotic dynamics."*

How are these changes better? I will comment line by line, including some corrections beyond the problem of over-specification.

Sentence 1. Since studies are countable, "amount" should read "number" in the original. One could say an "amount of work" because it is not countable. But we want fewer words to distract us from the main thought anyway. "Many" is better. The original is somewhat confusing: will the paper be about the generative processes of the field or the field in general? Is my revision what was intended by the real scientists? The phrase "completely known" is overreaching or vain.

Sentence 2. We don't need to say time intervals and years, especially when we also have "temporal behaviour." Also consider throughout the passage whether the term "behaviour" should be "rate" to be more precise. "Behavior"(American spelling) is one of those dangerously vague catch-all words.

Sentence 3. We don't need the double effect of "suggest" and "possibility." The verb "originating" is not transitive: it cannot pass action onto a direct object like "field." One could say "initiating" or "causing," but the second word has a bigger meaning. It is acceptable to say something "originates in" something else. I believe the first version too long for the information load it "carries."

Sentence 4. I rearranged this for better transition to sentence 5 and tried cutting repetitions in both. "This statement" has some ambiguous referents. (discuss)

Last sentence. The indefinite article is not needed because confidence is not a thing and is meant generally. The phrase 'a high confidence level" is correct, however. The concept of "prediction" means 'the future' so "ahead" is repetitious in the original. There is an awkwardness of number about "an dynamics." Use "a chaotic dynamic system," "chaotic dynamics," or "chaotic behaviour."

Here is an alternate, partial revision of the original passage, offered by my husband Dave from the viewpoint of more informed science.

"Recent work suggests that core fluid motions, the ultimate cause of the geomagnetic field, are chaotic. If so, then nonlinear methods should predict the geomagnetic field better than linear ones. The converse is true too: if nonlinear methods predict better, then chaotic flow is likely at work. To test for chaos, we thus compared a nonlinear prediction scheme to four well known linear methods. The nonlinear method predicted best, suggesting that core fluid motions are indeed chaotic."

Remember that what you can afford to leave out depends on your audience and the clarity of your transitions. However, trust your readers to remember at least the given subject. Try using synonyms for it after first defining them to be equivalent, as in "flooding" and "inundation," or "layers" and "strata." The resulting variety and sophistication keep readers happy and awake. They like to be given credit for understanding. If one says an area is "still of continuously high seismic risk," it is not necessary to say that "it experienced destructive earthquakes in the past" too.

Tool Three: Varying word order so that the subject comes in different places will also keep your clients - the readers - alert. No one likes an article that reads "tuh dum tuh dum tuh dum tuh dum" for 30 pages! The cumulative effect is childish and numbing. Here is an illustrative, short passage (8 sentences) that could be improved:
"Predicting individual earthquakes is not possible now, but long term probabilistic forecasts can be validated and provide useful information for managing earthquake risk. Short term probability estimates are important for emergency and scientific

response, but they are considerably more difficult to construct and test than long term forecasts. Here we present three different forecast models, along with some quantitative tests of their effectiveness. The three models are for a long term and short term forecasts based on seismicity, and for long term forecasts based on geodetically observed strain rate.
Our long-term seismicity model is described in Kagan and Jackson (1994) and Jackson and Kagan (2000). We made specific forecasts of earthquakes over magnitude 5.8 for two regions of the Pacific Rim at the start of year 2000, and we present here a true prospective test of those forecasts. The short-term model is much harder to test formally, but we show here some reasons to be optimistic. We also present a "pseudo-prospective" test (that is, using data collected after 1993 to test a model based on pre-1993 data) of the geodetic strain model for southern California."

There is nothing incorrect about this excerpt but it presents its information in traditional subject-verb order throughout. Sentences 1 and 2, moreover, use compound "but" sentences right in a row. Although the authors start with the lively gerund *"Predicting"* (evoking process) and use some good active verbs like *"provide," "present," "made,"* and *"to test,"* they overuse terms like *"model"* and *"forecast(s)."* (They try hard for variety in sentence two with the phrase *"Short term probability estimates."*)

The latter problem has some solutions. The verb *"to model"* has synonyms like *"compute,"* and *"estimate."* The noun *"model"* has some general synonyms like *"paradigm," "construct," "image," "method," "scheme,"* or *an understanding."* If we mean the noun *"model"* in its specific sense as a detailed set of parameters, we may have to stick with that word. Wherever possible then, use the other substitutes for variety. For the verb *"forecast,"* one can say *"estimate future behavior"* or more specifically *"estimate future rates"* as a variation.

Here is a possible revision for the original, rather boring passage.

"Predicting individual earthquakes is impossible now, but long-term probabilistic forecasts can be validated and provide useful information for managing earthquake risk. For emergency and scientific response, short-term estimates are important but considerably more difficult to construct and test than long term forecasts. Here we present three different forecast models, along with some quantitative tests of their effectiveness. The three are for long as well as short-term forecasts based on seismicity; for the long-term, they are based on geodetically observed strain rate.
Our long-term seismicity model is described in Kagan and Jackson (1994) and Jackson and Kagan (2000). For two regions of the Pacific Rim, we forecasted earthquakes over magnitude 5.8 at the start of year 2000. We present here a true prospective test of those forecasts. By contrast, the short-term model is much harder to test formally but some cause for optimism remains. Using data collected after 1993 to test a model based on pre-1993 data, we also present a "pseudo-prospective" test of the geodetic strain model for southern California."

What improvements can we see now?

Throughout I made long and short-term hyphenated adjectives to show that both parts of the adjectival phrase modify "probability" or "forecast."

Sentence 2. I left out *"they are"* to change the repetitive compound sentence format and tighten the thought up. The changes also delay where the subject comes and at the same time place the causal frame first: *"For emergency and scientific response,…"* The rearrangement has the additional benefit of placing the parallel adjectives *"important"* and *"difficult"* closer together on the page since they are logically.

Sentence 4 had a problem with mismatched number: *"a long term and short term forecasts"* which is now corrected.

The new sentence 6, like the revised second sentence, places the context first for logic and courtesy: *"For two regions of the Pacific Rim…"* I also transformed the noun *"forecasts"* into its verbal form for contrast with the later noun *"forecasts,"* now placed in a separate unit for length variation.

Sentence 7 begins with a new logical signpost, *"by contrast,"* which shows an important turn in thought first and eliminates the repetitive *"we present", "we made,* and here a *"we show"* formula. The final sentence defines a pseudo-prospective test in an order which delays the subject for more vivacity. Anything different is to the good! We are asking readers to absorb difficult information and think hard so we must give them all the help we can.

Remember to give them the advantage of all your work and preparation in a varied form. They will "stay with you longer" as a result.

I'll conclude this lecture with the prop for today: a spice jar. Since we are in Italy, food metaphors call out for use! As competent writers we need to deliver our findings with different techniques and *tempi* to keep the reader alert and our ideas memorable. Use punctuation, ellipsis, and variable word order to "spice up" your writing. (Using a "periodic structure" in which the meaning is completed only at the very end is another good technique. Note my prop, saved till last.)

Lecture 5

How Precise Can You Be? Controlling for Precision

Our props for today include some American, Swiss and Italian money. You may wonder how such currencies are related to scientific writing - beyond funding of course. There is method to my madness. Remember that in your professional work, there are three currencies for the exchange of information: tables, figures, and posters (the visual); numbers and formulae (the mathematical); and words. Just as we must use the correct currency in North America or Europe, so we must find the *"exact change"* or valid word for scientific writing and speaking. Without that word, we can't buy an editor's notice or the reader's attention. Today I'll make suggestions on such "purchases."

How can we withdraw the right words from the bank of English? "Diction" is the technical term for such withdrawal or word choice. In an acquired language our diction is sometimes incorrect or "off" (like food gone bad) because we only approximate the sound or spelling of a desired word. Here are some funny examples from American children at a Catholic elementary school. Since they are just learning the language, they make choices amusingly off the mark in sound or spelling. Find what is wrong below:

"The seventh commandment is thou shalt not admit adultery."

"Moses died before he ever reached Canada."

"David was a Hebrew King skilled at playing the liar."

"Jesus enunciated the Golden Rule which says to do one to others before they do one to you."

As we see, even one wrong word can undo your meaning!

I will use the children's references to the *"12 decibels"* or *"holy acrimony"* to ease us gently into more serious problems in our scientific papers and talks.

Similarity of sound misleads adult writers too, especially those who use a language not their own. I often see, for example, *"lower then 300-400 degrees centigrade…"* Of course the writer meant the comparative "than." Here's a typo which also has a similar sound to the correct word *"addition"*:

"More detailed evaluations of the topography and conductivity of the sea in addiction to the information from the assessment of a map of global conductance…"

The second word in red, *"conductance,"* should also be flagged in revision to make sure that it is intended. The writer must ask: did I mean *"conductance,"* which depends on shape, or did I mean the similar sounding word *"conductivity"* which does not? Whenever a word has a related cognate, be sure you have the right one on the page.

One way to check for the correct word choice is to read your draft out loud. Your ear will help your eye find words that are slightly off because you've heard quite a bit of English. The more you hear and read good users of the language like Peter Bird, Leon Knopoff, lay writer John McPhee, Ross Stein and my husband Dave, the better. They are more secure teachers of usage (when a particular word is more fitting) than is a thesaurus. Copy their "formulae" until you feel more secure about vocabulary and syntax. I also recommend Robert Hartwell Fiske's free online journal: www.vocabula.com. And as always, Bill Bryson.

One surprising example of a dangerous word for scientists is the conjunction *"or."* I strongly recommend flagging it: circle or mark it in some way as you revise first drafts. Ask yourselves whether *"or"* could also be an *"and."* For

example, could an event be both *"random"* and *"rare"*? Always consider the *'and/or'* format to check the completeness of your logic.

We've looked at nouns and conjunctions so far in our "precision search." Now let's consider verbs and verbals (gerunds), the all important engines of thinking on paper. Here are some sample problems:

- *"Main monuments were performed ..."*
- *"... together with the performing of a more suitable 3-D modeling approach"*
- *"... used these contemporary reports coupled with investigations performed from the 1970's by ..."*

Usage is "off" in these three cases. In the first it would be correct and idiomatic to say *"were installed"* and in the second, one should say *"with the use of a more suitable approach."* Consider this format too: *"He tried (also "investigated"* or *"experimented with")* a 3-D approach."

The third instance has several errors. Usually one *"conducts"* or *"begins" investigations* or better yet *"investigates."* I would also change *"from the 1970's"* to *"in"* or *"during the 1970s"* because "from" means "a range" as in 'from 1972-1975.' The apostrophe is usually left out now in the notation of decades.

Now we've seen some errors with this verb. But how can we use this good action word well? In science for example, we "perform" an experiment, analysis, or operation. Here are more incorrect usages with different verbs:

"For the Doctor house site the throws derived from the different trenches should be cumulated because of the presence of the three parallel scarps."

Perhaps the writer had in mind the adjective *"cumulative"* as a model. For example, one earns a *"cumulative score"* in different skiing events for a final total. Or the writer might have been thinking of the transitive verb (passing action on to a direct object) *"to accumulate,"* as in *"She accumulated possessions."* But there is no such form as *"cumulated."* I would rework the original sentence:

- *"For the Doctor house site, throws derived from the different trenches should be added together because three parallel scarps are present."* (frame set off, correct verb, and 3 fewer words)

- *"Their quality progressively reduces along depth, approaching the Moho…"*.

It is permissible but a little odd to say, *"Their quality is reduced progressively"* (past participle used as adjective). More often that construction is completed with a prepositional phrase as in:

"The quality of data is reduced by noise."

The verb *"to reduce,"* like *"accumulate"* above, is usually transitive: that is taking an object:

"She is trying to reduce clutter." ("*She is trying to reduce*" by itself means "to lose weight" and that is an understood object-size or weight).

I would rewrite this sentence like this:

"Their quality deteriorates (or "worsens") with depth approaching the Moho…" Now we have corrected the verb, preposition, and punctuation.

- *"Fictitious results can be conducted when 2-D analyses are performed over data in 3-D structures…"*

The verb here is non-idiomatic with its noun. Experiments and surveys are "conducted." (Surveys are also *"made," "taken,"* or *"performed.")* But results cannot be conducted. (Musicians resist it too!) Here is a possible set of fixes to choose among:

"Fictitious results can occur when 2-D analyses are performed on data in 3-D structure…"

"Artifacts may follow 2-D analyses performed on data in 3-D structures…"

"Fictitious results sometimes happen after 2-D analyses of data in 3-D structures…"

Now we have shorter, tighter expressions using idiomatic noun-verb combinations and a correct preposition. I have also tried to preserve the original's level of possibility in the new words: *"can," may,"* and *"sometimes."*

Here is another example of a verb usage error. It is not a problem with transitive, intransitive usage or possible noun-verb combinations, but excess. The indecisive writer hasn't chosen between two consecutive verbs:

- *"In their reappraisal they conclude stating that the first shock may have ruptured…"*

I would rework the line like this:

"In reappraising the results, they conclude (or "find" or "hold" or "maintain") that the first shock may have ruptured …"

or

"Their reappraisal states that the first shock may have ruptured…"

Other problems with those tricky but essential verbs come from overstating or understating your level of certainty. As writers relatively new to English, you may not yet know the intensity inherent in certain verbs. I have made below a chart in three columns of verbs and corresponding adverbs projecting the most tentative to the most assertive meanings. Please consider:

Part of speech	***Weak***	***Strong***	***Stronger***
Verbs	may, might,can, could	should	will, do, must, have to
	suggest, believe	deduce, think	conclude, find
	guess, suppose	estimate	Assert, maintain know
Adverbs	perhaps, conceivably	Probably, reasonably, rationally	certainly, definitely

Writing precisely means choosing a word from the correct column of certainty. You want to avoid timidity as much as arrogance in stating your findings. If, for example, your confidence level is 30%, pick from column one; if you have a 95% degree of certainty, choose from column three. It also helps to use tempering adjectives like *"a tentative result"* or a *"conceivable theory"* or a *"reasonable model."*

One important reminder here: if you are speaking of hypothetical cases about which there is no certainty, use the subjunctive. It is a mood of the verb which is rapidly disappearing but indicates an educated precision. It is heard in the helping verb forms: *"should, would, may, might."* It is indicated often by moving the verb into the past, as in *"If we were to trench the fault, we might see…"* Be careful not to go in and out of the subjunctive once you have started it; in other words stay with "would" and don't move back into the indicative mood with *"will"* (saying what is, a condition of fact) For this advanced skill, see pages 182-3, 191-2, and 217-8 in Bill Bryson. I also recommend his excellent bibliography of reference books.

Knowing the difference between the indicative and subjunctive is truly important for scientists who, after all, study factual evidence and propose hypothetical models to describe it. Show that you know the difference by using the mood of verbs precisely.

Just as words can be arranged on a metaphoric *"number line"* of increasing certainty and conviction, so can they be arran-

ged for intensity. This is another parameter we face in choosing the right word. For example, it is quite different to say,

"I am puzzled (or confused) by your results."
"I am troubled by your results."
"I am amazed (or astounded) by your results."
"I am confounded by your results."
"I am annoyed by your results."
"I am angered by your results."
"I am appalled by your results."

"I question your results."
"I contest your results."
"I dispute your results."
"I have no respect for your results."
"I can negate your results."
"Your results are unsupported/untrue/stupid/ridiculous."

All the above sentences are correct but convey different intensities of meaning. In first drafts of your papers and talks, be sure to circle those past participles used as adjectives (like *"puzzled"*), simple adjectives (like *"untrue"*), and verbs like *"dispute"* to make sure they say what you mean, no more and no less.

Finding that "exact change" will get easier as your English competence increases. Don't despair! You will get more of a feel for the connotations or "aromas" that English words give off.

Keep in mind that even native speakers of all languages get stumped for the right word or word combination. Diction is a great challenge for all, and even more so for those bravely using a foreign language! As coping mechanisms, I recommend the following.

Listen to and read as many good English speakers/writers as possible. Keep a "commonplace book" of language that you like. Practice using those words and phrases to assimilate and later change them into your "idiolect" or personal language.

Write frequently, even before your research is complete. That way you will find what you're thinking and define your problem as you go along. Writing, like mathematics, is a process which helps us organize ideas and locate what we know. Frequent practice makes us less afraid of writing and more fluent (a biofeedback loop!)

Don't stop when you are stuck on an elusive word in your first draft (or second, third…). Leave a blank and continue so the missing correct piece will not stop your creative momentum. Go back later and try a few near synonyms out loud. Ask for peer help and brainstorm different versions.

So far we have discussed the more precise use of some nouns, conjunctions, and verbs (absolutely precise is a pipe-dream; we are always halfway to that door, as in Xeno's paradox). Our next challenge will be the devilish indefinite versus definite article. When should we use the one, when the other? We all know the old rule that when we have already identified a particular case of something or someone, we use *"the."* Suppose that the following examples have been previously defined:

"The data are sound."
"The datum is contaminated by noise."
"The evidence is unconvincing."
"The pieces of evidence are substantiated."
"The tectonics of California is far from understood."
"The dynamics of convection is complex."

All the above are grammatically correct, but the last two use singular collectives, like *"evidence."* I recommend that

you get around this incongruity of a singular with an "s" plural ending by using a construction that does not depend on singular or plural number. For example,
'There is no comprehensive understanding of California tectonics."
"Convection exhibits complex dynamics."

But you could also say: *"tectonics is"* or *"tectonics are far from understood"* or *"Convectional dynamics are complex."* The advantage of our crazy English is flexibility! Remember from an earlier lecture that the definite article "the" is not used when you want to convey a general process like *"tectonics,"* *"convection,"* and *"dynamics"* above. See also *"conductivity"* below:

"GDS provides useful information on the distribution of electrical conductivity in the lower crust and upper mantle."

In other words the elegant absence of *"the" before "conductivity"* gives important information. Also the writer has chosen to isolate or highlight the distribution and the crust and mantle.

The same absence rule holds to indicate a period in general, as in: *"From late Miocene times..."* (green). However, if you want to leave out *"times'* or *"period,"* you must say *"From the late Miocene…"* to let the reader know Miocene is being used as a noun.

To summarize these options, consider the following expressions (all correct) which turn upon *"a"*, *"the"*, and the article's absence. Each conveys a different message which I put in parentheses.

"for studying a conductivity profile..." (any profile not previously singled out)
"for studying the conductivity profile..." (the one previously described)
"for studying conductivity profiles..." (the general class of profiles which must be plural)

Be very careful in practicing this difficult skill. Remember that when you talk about uncountable "stuff" or amounts before which you can place *"some,"* use no indefinite article as in *"water."* Not *"a water."* However, if you have referred to specific "stuff" like the water of the Imperial Valley, you need the definite article.

I have noticed errors like the following from the acknowledgment section of papers: *"We offer a special thank to..."*. The correction would be either: *"We offer a special thank-you to"* or *"We express special thanks to..."* (both green because "a thank-you" is countable and "thanks" or gratitude is uncountable "stuff.").

Here's my final example of how important diction and in particular the article can be. International politicians at the February meeting in Brussels are struggling with the text of the European Constitution, Article 2. They must agree on the wording of Europe's relation to the transcendent. Some want to say "God;" others will refer only to Europe's "indivisible, universal values" and "spiritual and moral heritage." They are also fighting over the following indefinite article: *"God is a source of truth."* Quite different would be the phrase *"God is the source of truth."* (How apt that this is in "article 2"). Similarly, in the German version of the Charter of Fundamental Rights of 1999, Germany preferred Europe's *"religious"* heritage (more traditionally sacred and more specific) to the French translation: *"spiritual"* heritage (more general and secular).

Be sure that you make your word choices consciously. Remember that the meaning you want doesn't just happen. It must be achieved. You have to dip into that ever growing, personal 'word bank.'

For our next lecture, we'll talk about more problems with precision, including number mismatches, incorrect prepositions, and "wiggly" or ambiguous and vague pronouns.

Just remember that some imprecision comes from presence: the wrong word is unfortunately there. Other forms come from absence: insufficient words for clarity. Finding both forms works best when you allow time between your drafts and your revisions. Seeking an objective peer reader will also help isolate these problems.

As your revising skills improve, you will be pleased to see what's in your head and what's on the page come closer together. They may not match but will at least peacefully "cohabit."

Lecture 6

More Precision Tooling

We continue our work on usage from the last lecture by looking at other kinds of mismatch. What prop can remind us of this problem? Note these mismatched shoes: neither color nor size work together (a grievous error in fashion conscious and leather expert Italy). Unfortunately, some writing features equally odd combinations where number, prepositions, and pronouns are each badly paired. Such mismatches are dangerous because they interrupt logical continuity and undermine the writer's credibility as an intelligent, careful source. Let's look at some examples to hone our revising skills.

Skill One: Avoiding subject-verb disagreement

We must control agreement between subject and verb to underline their grammatical connection for the reader/listener. Such continuity is lost in the following examples. It can be restored if we let grammar and our ear help us. For example, look at sentences 1through 5. I have italicized their singular subjects and mismatched plural verbs to help you. Now separate out the confusing prepositional phrases following the subjects. Those adjectival phrases beginning with *"of"* or *"from"* contain plural words which might perturb you temporarily. Read the sentence out loud without the phrase to isolate the logical subject and hear its true number.

I give the correct verb in parentheses after each mistaken sentence and make some other suggestions as well.

1. "As already mentioned *this type* of *constraints were* not enough considered in the available literature." (*"such constraint was" "this type of constraint was" or "these types of constraints were slighted or overlooked in the available literature."*)

2. "*Dating* of charcoal fragments collected above and below it *constrain* the age…" (The gerund or verbal form *"dating"* is the true subject. The fragments themselves cannot constrain the age, can they? So…*"Dating constrains…"*)

3. "*Understanding* Apennine Geodynamics from recent large earthquakes *are* ..." (Don't let the apparent plural of the collective "geodynamics" in this long subject clause fool you. The gerund understanding is sg. *"Understanding… is"*)

4. "*This kind* of monuments *are* provided *of* auto-centering devices..." ...(*"This kind of monument is provided with ..." or "Such monuments are installed with…"*)

5. "The CA-GeoNet *consist in* 126 non-permanent and 3 permanent stations..." (A network is a collective entity treated as one thing having several parts. *"The Ca-GeoNet consists of..." or "The Net has 126..."*)

6. "The *presence* of several Quaternary marine terraces *attest* to…" (*"The presence… attests to…" or "Several Quaternary marine terraces attest to…"*)

7. "Finally the *expansion* of the Earth *and* then an increasing *gravity finds a new support* in the forecast of an oscillating path of the True Polar Wander, *which* has been already observed." (This sentence has two subjects shown in italics so the correct verb must be *"find new support in…"* The support is in general so we use no article). I'm not sure how to rewrite this because it confuses me but I will try this: *"Finally, the expanding Earth and increasing gravity find new support in the observed oscillating path of the wandering pole, a path which had been forecasted."* That's an interpretation only because the overly long original doesn't work in English. We'll return to this example in a later section on ambiguous pronouns.)

8. "The *origin and significance* of an enhanced conductive layer in the lower continental crust *is still an open question…*" (Like 7 above, this sentence has a *compound subject* -"*origin and significance*"- which requires the plural predicate *"are still open questions."*)

Skill Two: Avoiding modifier-modified disagreement (two red examples)

1. "Most of us have *a lot of problem to write* a comprehensible English..." (This sentence has several problems, fittingly enough. The basic one is that the adjectival prepositional phrase *"of problem"* doesn't match its noun, *"lot."* The sentence is also too casual in using *"a lot,"* a conversational phrase employed for "amount words" which cannot be counted. One could say informally, *"I'm in a lot of trouble."* But *"problem"* in this sentence wants to be plural and "problems" can be counted. I would say instead: *"Many of us have problems in writing comprehensible English."* The indefinite article is a little awkward but not really wrong because it implies a comprehensible text.

2. "Some of *this normal faults* have…" (Like examples 1 and 4 above, there is tension between *"this"* (sg) and *"faults"* (pl). A possible fix: *"Some of these normal faults have..."*. There is no problem or mismatch between the true subject *"Some"* and the plural verb *"have."* Here the error is only in the adjectival prepositional phrase starting with *"of."*

But here is a tricky correct example in which a modifying word is plural but the main noun is not:

3. *"As shown in Figure 16, the general data trend is satisfactorily reproduced…"* (Green because what is understood is *"a trend in or of the data"*). A parallel example is "People power is important."

Skill Three: Avoiding number problems from missing endings or articles

1. "As the ILP II-5 activities evolve with time, new contributors and *proposal* will be initiated." (The noun "proposal" needs some kind of article or a plural ending coming after "contributors" in a parallel slot. A possible fix: *"new contributors and proposals" or "new contributors and a proposal..."*)

2. "I will also check for the Kathy's seminar." (I love this charming error because it reminds me of the satiric title for vainglorious Mr. Trump: "the Donald" as if he were the ultimate or King Donald. Number 2 here hints that there might be several Kathys available to give the seminar so the author is referring to one previously identified from that larger group. I think he meant: *"I will check to see if we can schedule the seminar Kathy might give."*

Skill Four: Avoiding non- idiomatic number errors

"The *equipments are* ready..."	*"The components/meters/devices/ Motors, are ready…"*
"The *advices were* good..."	*"The pieces of advice/The suggestions were good…"*
"The *evidences are* sound..."	*"The pieces of evidence/the data/the facts are…"* *"The observations are sound..."*

In all three cases above, the noun subjects are singular collectives taking singular verbs: equipment is, advice was, evidence is. If you wish to use a plural verb, see column two above for corrections.

While on the subject of number errors, remember that we can also err in writing numbers. When a number is only one digit long, it is customary to write it out as a word, as in "*three splayed faults*." Any number longer than

one digit should not be written as a word. If you are using a standard abbreviation of units like km, cm, or m, it is acceptable to use a numeral, not word, for any number. Do not use an article before a numeral that is a power of ten, only before the written word as in "1,000 tests." and "a hundred iterations." One other note: try not to start a sentence with a numeral.

One general piece of advice on deciding number problems: look at each clause separately. Don't let the plural subject of the dependent clause confuse you about the main clause with its singular subject!

For very good counsel on overall number problems, see pp. 139-143 in Bill Bryson's Troublesome Words.

The good news to comfort us is that numbers are familiar to scientists. With that in mind, you will soon be adept in fixing any number mismatch between subject and verb, modifier and modified, and article and noun.

Skill Five: Using prepositions to match context

A preposition which "sticks out like a sore thumb" is common in the English of foreigners because our prepositions are so idiomatic and troublesome. Here are a few incorrect examples with corrections in parentheses:

1. "We are a little bit *on* late." *("We are a little bit on the late side."* or *"We are running late"* or *"We are a little late."* Or *"We are relaxed Italians." "On"* is only possible in the first case. One could also say, *"We are behind schedule")*.

2. "I will also check *for the* Kathy's seminar." (Fix: *"I will also check on Kathy's seminar."* See above as well under skill three.)

3. "The most numerous methods of EQ prediction are mainly based on the search *of* EM precursors…". This unintentionally means the EM precursors are themselves conducting a search, as in the following correct sentence: *"The search of the hiring committee will be completed soon"*. (Fix: *"Most methods of EQ prediction look for EM precursors"* or *"The search for EM precursors is central to most methods of EQ prediction."*

4. "We believe that EM precursors may happen *in occasions of* seismic activity." (should be *"on the occasion of"* but better yet would be this fix: *"We believe that EM precursors may occur during seismic activity."*)

5. "The Gubbio basin has the peculiarity *to be* a narrow, NW-striking, elongated depression." (This use of the infinitive in the apparently infinite mood - see Bill Bryson, p.239 - is not idiomatic. It would be much better to use this fix: *"The Gubbio basin has the peculiarity of being…"* Or you could say, *"As a narrow, NW-striking, elongated depression, the Gubbio basin is oddly shaped."* Or *"has an odd shape.")*

6. *"The middle Miocene to Pleistocene eastward frontal accretion was simultaneous to back-arc extension."* (Fix: *"Eastward frontal accretion during the middle Miocene to Pleistocene happened simultaneously with back arc extension."* Or *"was simultaneous with"* or you could make the subject compound, as in *"Back arc extension and eastward frontal accretion during the middle Miocene to Pleistocene happened simultaneously."* What you don't want is *"to"* and the seven-word subject of the red original.)

7. *"I will ask to my colleague."* (Fix: no preposition before direct object with this verb; also true of the verb "question," as in *"I will question the reviewer."*)

8. "The main problem *consists in* the low signal-to-noise ratio." (Fix: say instead: *"comes from"* or *"is."* Usually we say, *"consists of"*.

Prepositions are really the bugbear of English! Here are a few more correct, idiomatic combinations of prepositions, verbs, and nouns to memorize and play with:
"characteristic of"
"measurements of," "for," or "in the frequency range"

"resolve by"
"results on" or "for" but *not "of"*
"cope with" "variations in" "differences between" or "in"
"Experiments by" or "the experiments of Jackson"
"on the contrary" "contrary to" "in contrast to"
"inquire at" or "in the office;" "inquire of a colleague" is quite formal
"independent of" in general but "America won its independence *from* Great Britain." (to stress action, achievement)
"uncertainty about" or "concerning"
"difficulty in recognizing/ difficulty of recognizing/ difficult to recognize"
"on the order of"
"having focused our interest on"
"the surface of the upper crust is well known from "
"are susceptible to contrasting interpretations"
"to obtain independent results for constraining"

A last reminder about prepositions in general.
Use them sparingly and kill three birds with one stone: reduce wordiness and passives, and avoid non-idiomatic usage. Try to turn each prepositional phrase into a one-word modifier instead. For example, rewrite the following:

"We had a positive response from scientists from several countries." (two unnecessary examples of the same preposition in a row)

"We had a positive response from international scientists." (the original adjectival phrase "from several countries" as a one word adjective)

Turn "information *"of good quality"* into *"reliable"* or *"sound information"* (3 word adjectival prepositional phrase now 1 adjective)

Turn *"in the vicinity of"* to *"near"*

Remember to bank your words for important ideas. Don't "withdraw them" in the form of prepositions (lesser players than verbs and telling nouns). Every preposition uses up some of the reader's (listener's) attention so use only the necessary ones. The sooner you get to your important information, the more impact it can still have.

For translating wordy prepositional phrases and other jargon-heavy language, I recommend Appendix 4 in Robert Day's guidebook, "How to Write and Publish a Scientific Paper," 3rd edition, Cambridge University Press, 1989. It also has a helpful chapter on usage (27) and a good reference section.

Skill Six: Avoiding wiggly or ambiguous relative pronouns

Careless writers are often bewitched by the word *"which."* They use it to tack on a dependent clause but forget that readers cannot always parse which part of the preceding sentence that *"which clause"* applies to. All of it? Part of it? Just the immediatelypreceding word? Precise writers/speakers never confuse the reader/listener in this way.

Precision requires that you the writer do all the thinking work first, laying out your meaning with no wiggles or wobbles. Then readers will respect your rigor and save their thinking energies for your ideas.

Let me show you how ambiguity happens with dependent clauses—those that cannot stand alone but latch on to a main subject-verb clause. Then we can revise.
Here are some erroneous examples of vague relative pronouns and their corrected versions.

1. "We could provide a longer time frame to assess the tsunami recurrence and *hazard* of the study areas, *which* is currently based solely on the historical information."

Since "is," the verb of the dependent clause, is singular, we might assume that "which" refers to the nearest singular noun, "hazard." Or we might go back further to assume that the antecedent is "a longer time frame," the direct object of the main clause. Or perhaps the "which clause" refers back to the act of assessing? I would not know the correct choice from the clues given by this sentence. One interpretation might be:

"We can expand the historical information which is now used to assess tsunami recurrence and overall hazard in these areas." You can also omit "which is" because it is understood. This new sentence works because I have *reordered the words to clarify their logical continuity*.

Such reordering is an important revision skill for cleaning up ambiguous dependent clauses.

Here's the other revision skill to try on these troublesome units. First the challenge:

2. a. *"In the northwest sector of the studied area an anomalous high conductivity behavior is superimposed on the regional trend, which corresponds to the geothermal field of Larderello-Travale."* In this case again, we deduce from the singular verb "corresponds" that the antecedent is either "trend," "behavior," or the WHOLE superimposition. The wobbly meaning needs revision. It could be broken into two sentences, one about local effects and one about regional. Another *possible* fix might be:

"In the study area's northwest sector, we see an anomalously high conductivity added to the regional trend, a combination which corresponds to the geothermal field ..."

I tried to improve the original by getting key words closer together, setting off the introductory frame, and adding a clarifying noun, *"combination,"* before the relative pronoun. I'm not sure if this is a true restatement, but it at least says something clear. And as usual, suspect that catchall term "behavior." It can be very fuzzy. Try to use more specific terms that really "triangulate" your meaning.

Here is a second example of using a clarifying noun before the ambiguous dependent clause to show connection better. Remember this example under Skill one?

b. "Finally the *expansion* of the Earth *and* then an increasing *gravity finds a new support* in the forecast of an oscillating path of the True Polar Wander, *which has been already observed*."

It is a heavy sentence to deconstruct because the "which" might apply to several antecedents. It might mean:

"Finally, the expanding Earth and increasing gravity find new support in the observed oscillating path of the wandering pole, a path which had been forecasted."

Since we are talking about precision today, a small digression about another "lazy" term that has become a buzz phrase. Always flag the word "behavior" and watch out for "paradigm shift" too. Here is a vague example: *"The objective was to produce a paradigm shift in Indian society regarding earthquake hazard from the next M 8 earthquake..."* (red). Such a term can be as wobbly as unsecured "which" clauses. Instead define what you mean by this clichéd buzz phrase when you first use it, if you do.

Before leaving the difficult issue of loosely connected dependent clauses, let me say a few words about "that" vs. "which." Like the subjunctive, the distinction between them is disappearing in casual speech and writing. But if you wish to be very clear in sending your meaning, use "that" only for defining clauses: those that cannot be left out. For example, *"The fault that I have been trenching for the last five years is now rupturing."*

This example is correct because the dependent "that clause" defines the particular fault in question. Ask yourself before choosing between "which" and "that" if the antecedent noun is the answer to the following question: Which one? That particular one only. Use no commas around such essential clauses.

Here is an example of a correct "which clause," non-essential through and through.

"The San Andreas Fault, *which runs northwest*, was the source of the 1857 earthquake."

If you can leave a dependent clause out and not seriously change the meaning of the main clause, use the *"which"* format and surround it with commas. I find it easier to understand if I group *"which"* with the indefinite article *"a"* and *"that"* with the definite one, *"the."* The parallelism helps me decide when to use each. But it is hard for native speakers too!

See Bill Bryson, pp. 197-199.

Now that we all have headaches from trying to think more precisely (Writing really is a good mental discipline!), let's return to our first prop: the mismatched shoes. Using the six skills we have discussedy will correct that problem so that your grammatical units will match in "size and color." They will not only fit but also transport your ideas.

Lecture 7

How to Make Our Writing More Energetic

Lively animated writing stays with the reader. That's what we want. But how can we make that happen? Here I'll focus on three ways to give our words more energy: using active verbs, varying sentence type, and varying diction level. When used correctly, these techniques will give your writing the "kick" or engaging movement conveyed by today's props: a running shoe and sweatsuit (after all, writing well is a workout).

Skill One: Using Active Verbs and Verbals

Past lectures have addressed some problems in using verbs like number and preposition mismatch or transitive/intransitive errors. Today we'll look at other problems to avoid. Why is this so important? A verb used well moves your thought along and engages the reader in its action: two great goods.

The following examples of increasing difficulty show how to "juice up" your sentences with stronger verbs.

Let's start with a verbally correct and simple example that is rather pallid:

1. *"The origin of the Earth magnetic field is still one of the most debated topics in geophysics."* (17 words)

   Readers would "listen up" more if you said:

   "Geophysicists still debate the origin of the earth's complex magnetic field." (11 words)

   This fix adds more energy by using the base form of the verb rather than an "is and past participle/adjective" format. I also fixed some omitted words and combined some information from the next sentence (complexity) to explain the debate. Presenting uncertainty about the field more actively gives the paper a stronger, causative frame too.

2. *"Moreover, the result that the nonlinear method is the best approach to forecast, in this case one year ahead, the secular variation of the geomagnetic field is not really a surprise."* (31 words)

   This complicated sentence uses the weak state of being verb *"is"* in both the main clause, *"the result is not really a surprise,"* and in the imbedded dependent clause "that the nonlinear method is the best..."

   To fix this sentence and inject some energy, I will focus on the good active verb *"to forecast"* and add another one too (see underlined):

   "Not surprisingly, forecasting by one year the secular variation of the geomagnetic field works best with the nonlinear method." (19 words)

   I made the original verb *"to forecast"* into a verbal or gerund which still conveys energy. Gerunds thus make great substantives. (While on this subject, remember that it is correct in English to use a possessive before gerunds, as in *"Our forecasting by one year..."* or *"His going to the site for data collection at the trench was delayed by a tsunami."*).

   Unlike the static verb *"is,"* the active verb *"works"* gives our revised sentence the energy of doing. *"Works"* is also a great, short proletarian word which relieves the complexity of *"secular variation," "geomagnetic,"* and *"nonlinear."* I wanted to put the concepts of *"forecasting"* and *"nonlinear"* success close together as they

appropriately are in the original but add as well the strength of first and last slots.

Here is another sentence weakened by the dull verb *"is:"*

3. *"Geologic identification of large active faults is normally a viable alternative, but in Italy this approach is traditionally fraught with uncertainties due to the complexity of the country's tectonic history."* (30 words)

   We revise for verbals and active verbs to:

   "Identifying large active faults geologically normally works, but Italy's complex tectonic history subverts (or "hampers" or "weakens") this approach." (15 words)

   How do we make this process work? First, look for the key concepts in the original, as in the words *"geologic identification," "normally viable,"* and *"fraught with uncertainties."* Then try converting those concepts into verbals-gerunds, active verbs, and adverbs. Avoid putting your key thoughts in "the abstract noun-adjective-is" format of so much correct but pale writing. The revision will add 'color" if not charm! And don't worry, if I may continue this pun, about the "quarkiness/quirkiness" of making history *"act."* Old-fashioned stylists resisted what they call "anthropomorphizing non-humans, as in *"The data indicate..."*

I think the greater good of animating your exposition so that it will be remembered outweighs such pickiness. I would also argue that the active verb route cuts 'waste words." Note the word counts above! But you decide and abide by your journal's rules. Of course, I prefer that you start a quiet revolution of good, lively writing!

Before leaving the topic of "verbing thought," if I can invent such a word, please remember the following suggestions on usage.

1. I have noticed a tendency to interrupt a verb phrase with adverbs. This is especially awkward between helping verbs. Always keep main and helping verbs close together. This is another example of keeping modified and modifier cosy. For example,

   "should be thus considered" should be *"Thus, should be considered"*

2. If too many cooks can spoil the broth, so too many adverbs can spoil the verb. Sometimes writers will use adverbs as intensifiers, grouping them redundantly around the verb. The following is not a bad example, but it doesn't achieve its intent, partly because it is part of a sentence of 25 words.

   "... they certainly contributed significantly to the development of seismology as a science." (12 words)

   It would be better to select only one adverb - don't keep pouring more water into your coffee. More words do not necessarily make things better! Try:

   "They have contributed significantly to the developing science of seismology." (10 words)

   Too many adverbs is as unwieldy as too many adjectives as is the case with *"seismogenic"* here:

   "On the other hand, these results may shed light on the seismogenic potential of other seismogenic sources threatening the area."

   A fix would be:
   "However, these results may clarify the potential of other seismogenic sources threatening the area." (removes the unpaired "on the other hand," prunes the verb down, fixes spelling.)

3. I have observed some confusion about the simple past. When an activity/ process/event is completely over, use the simple past. Here is a mistaken sentence:

"A geomagnetic depth sounding survey covering the Northern Apennines of Italy has been carried out in the period 1992-94". Using the helping verb *"has"* or *"have"* would mean that the action started in the past and continues into the present, as in *"I have been teaching for many years."* But this action is finished. So the sentence should read:

"A geomagnetic depth sounding survey covering… was carried out in 1992-1994."

4. Finally a word on using tense to describe your research in a paper. All the work preparatory to your findings should be described in the past, as in *"we trenched, we investigated, we integrated."* The first verb you use is the point of origin for others. It helps you decide what form of past to use. For example, steps taken or events in a past more distant from the first reference need the helping verb *"had,"* as in *"The fault had ruptured before the tsunami struck."* But the findings themselves once published are considered to hold truth in the present. That tense of the verb shows respect for the labor of discovery. In other words use the present for established knowledge. Your conclusion should be full of present tense verbs like *"We find…"* In his 1989 third edition of *How to Write and Publish a Scientific Paper*, Robert A. Day treats this difficult subject well. The important thing is consistency.

Skill Two: Varying Sentence type: Using the interrogative and imperative forms

Earlier lectures have stressed the value of varying sentence length and subject-verb order because all deliberate, timed variation in writing keeps the reader awake and interested. Changing some parameter at the most important points you wish to make will underline those ideas. If your sentences have been moderate to long, write a short one for an important finding. Set it off by itself. Don't always start your sentences in the same way. Give the reader "a break" by delaying where the subject comes.

This rule applies equally well to varying sentence type. In the above paragraph, for example, I used four imperatives for the last four sentences: *"write," "set if off," "don't always start,"* and *"give the reader..."* In paragraph one under skill one, I changed pace with an interrogative or questioning format: "Why is this so important?" Here are a few examples of how such changes invigorate correct but rather dull writing.

1. *"Is also important to observe that it is quite stable regarding the error associated to each observatory in the sense that it is not very sensible to the noisiness of the time series."* (33 words)
This declarative sentence stating information is roundabout or unnecessarily wordy. The main clause says only, *"It is also important to observe."* (The subject pronoun was left out by mistake). The really important matter is demoted to the following dependent clause.

   Revise it into an imperative or gentle command to the reader:

   "Observe (or "note") that NFA yields a stable estimation error at each observatory since it filters out noise in the time series." (20 words) My interpretation would of course benefit from talking with the scientist, as always.

   This fix cuts out fat, fixes the prepositional error associated *"to"* (should be *"with"*), and the usage error *"sensible to"* (should be *"sensitive to"*). However, its most important benefit is a change in energy level. The reader is quietly reading along and is made to wake up with a command: "Observe." Even though the main thrust is still in a dependent clause, only two words precede the kernel thought *"NFA yields..."* and all the key concepts are brought closer together than in the original.

   Or you might choose to keep a declarative sentence and just omit "observe that." But I like the change in sentence type to the imperative with its wonderful wake-up call. Such a change at an important node of thought is strategic Please practice using the gentle imperatives of verbs like: consider, observe, note, refer to.

   Another possible fix for the original sentence is to pose a question, as in:

"What benefits does the NFA method offer? By filtering out noise in the time series, it yields a stable estimation error at each observatory." Like the imperative above, interrogative formats alert the reader through variation. Please use them frequently, especially in titles. They are always catchy.

Here is an excellent example from a paper by Ross Stein, a geophysicist at USGS, Menlo Park. He writes well and uses a question strategically:

2. *"The calculated off-fault stress increases are rarely more than a few bars (1 bar = 0:1 MPa, which is approximately atmospheric pressure at sea level), or just a few per cent of the mean earthquake stress drop. In addition, the proximity to failure at any site is presumably variable but in any event unknown. So why would aftershocks concentrate at the site of such small stress increases?"*

   The question propels the reader into the next section of the paper and also contains a good active verb: *"concentrate."* (A section of this paper is included at the end of this lecture to illustrate Stein's combination of active verbs (underlined) and passives (in bold). There is the rhythm of variety in such use. He is always a clear writer.)

As I have said in earlier workshops, questions are a wonderful way to pose problems, convey doubt, and indicate areas for future research. As with imperatives, try using at least four in every paper! Do a search for every period and think about the kind of sentence it follows. Could it be posed as a question or imperative for variety?

Skill three: Varying Diction Level

Just as athletes use a "change-up" or offspin in volleyball and tennis serves, or baseball and cricket pitches, so we writers should spin our diction. If you have been using difficult, abstract terms of art like *"resistivity," bioerosion," "synchronous," "monochromatic," "sedimentological," "paleoseismological," "seismogenic," "tomography"* or *"lithospheric roots,"* refresh the reader with a less formal and more concrete term. Try a lower or more casual word. Instead of *"implementation,"* say *"use."* Movement between these levels, like changing pitch in music, enlivens your writing. It will also usually change the length of the words, a bonus "change-up." Here are some examples with revisions tracked in by underlining. I have underlined simpler terms mixed in with more difficult ones. This mix was especially important since the text was written for non-professionals. Audience must always dictate word choice.

1. *"Combining paleoseismological and archaeoseismological evidence suggests that (1) the typical repeat time for individual, major Italian earthquake sources is 1,000-3,000 yr, and (2)apparently shorter recurrence intervals result from multiple sources or stress triggering of events on adjacent sources. These findings are supported by missing "twins" of the very same earthquake throughout history."*

   Note the hominess of *"repeat time"* rather than *"recurrence intervals."* Lay readers will be grateful for the relaxed metaphor of *"missing twins"* after working their way through *"archaeoseismological"* and *"stress triggering."* However, such occasional relief is welcomed by scientists too. All readers need a change-up to keep them attentive.

2. *"Although the infrequency of Italian quakes is clearly favourable, the mismatch between typical repeat times and the length of the reliable historical record (~700 yr) implies that several important and potential earthquake sources are absent from current historical catalogues. One of them could go off in the next large earthquake, turning it into yet another "unexpected event."*
   Should we then suspect historical catalogues? Of course not."

   What is good about passage two from the same document? The language is relatively ordinary or 'lay.' There are occasional high level terms like *'infrequency'* and *'potential,'* but the whole section comes as a breath of fresh air after prior paragraphs on 'trenching' and 'predecessors.' We are grateful to hear *"unexpected event"* rather than *"anomaly"*. But what really wakes the reader up through variation is the colloquial and visual image of "going off" and the casual, sentence fragment answer to a good question: "Of course

The role of stress transfer in earthquake occurrence

Ross S. Stein
US Geological Survey, MS 977, Menlo Park, California 94025, USA

An earthquake alters the shear and normal stress on surrounding faults. New evidence strengthens the hypothesis that such small, sudden stress changes cause large changes in seismicity rate. Rates climb where the stress increases (aftershocks) and fall where the stress drops. Both increases and decreases in seismicity rate **are followed by** a time-dependent recovery. When stress change **is translated into** probability change, seismic hazard **is seen to be strongly influenced by** earthquake interaction.

During the 75 years before the great 1906 earthquake on the San Andreas fault, the San Francisco Bay area suffered at least 14 shocks of moment magnitude (Mw) equal to or exceeding 6; these occurred on all major faults, and included two events of Mw > 6:8. In the succeeding 75 years, there was but one Mw > 6 shock1 (Fig. 1). Elsewhere, Mw > 6 earthquakes in the extensional regime seaward of subduction zones occur, with few exceptions, only in the years following great subduction events2. Evidently, the rate of seismicity is therefore not constant, and the rate—or probability—of earthquakes on one fault is not independent of the rate on another. Yet there is nothing in probabilistic seismic hazard assessment (the principal tool of the engineering, insurance, financial, and emergency- response communities) that reflects or can reproduce such observations. Earthquake interaction is a fundamental feature of seismicity, leading to earthquake sequences, clustering, and aftershocks. One interaction criterion that promises a deeper understanding of earthquake occurrence, and a better description of probabilistic hazard, is Coulomb stress transfer.

Coulomb failure stress

An earthquake reduces the average value of the shear stress on the fault that slipped, but as Chinnery first showed in 1963, shear stress rises in more areas than just the fault tips3. The importance of this discovery **was realized** about 20 years later, when lobes of off-fault aftershocks **were seen to correspond to** small calculated increases in shear4 or Coulomb stress5, 6. In its simplest form, the Coulomb failure stress change, Djf (also written DCFS or DCFF) is

xxx x xx x = yy y yyy (equation)

where Dt is the shear stress change on a fault (reckoned positive in the direction of fault slip) and Djn is the normal stress change (positive if the fault is unclamped). DP is the pore pressure change in the fault zone (positive in compression), and m is the friction coefficient (with range 0±1). Failure is encouraged if Djf is positive and discouraged if negative; both increased shear and unclamping of faults promote failure. The tendency of DP to counteract Djn **is often incorporated into** equation (1) by a reduced 'effective' friction coefficient, m9 (ref. 7). The calculated off-fault stress increases are rarely more than a few bars (1 bar = 0:1 MPa, which is approximately atmospheric pressure at sea level), or just a few per cent of the mean earthquake stress drop. In addition, the proximity to failure at any site is presumably variable but in any event unknown. So why would aftershocks concentrate at the site of such small stress increases? ...

not." Such change-ups are like different courses in a meal; we no more want to eat pasta, pasta, pasta, than we want to read over and over and over abstract Greek and Latin nouns of high formality and erudition. The writer has done well to recognize his audience and take pity on them.

One warning, however: be careful that the synonyms from a different level of diction are defined when first used if there is any ambiguity.

Before concluding, a few words on Robert Barras, *Scientists Must Write: A Guide to Better Writing for Scientists, Engineers and Students*, Chapman and Hall, 1989. It is far more formal than the American Robert Day's more

amusing book (also 1989) and somewhat more dated, but useful as a British "take." In previous lectures I recommended Day's appendices, especially appendix 4, glossary of technical terms, and references. My favorite pages were pp. 187-189. In the Barras study, I especially like Tables 6-9, 11-15. Look at pages 30-48, 57-62, and 73-77. See Chapters 8 and 9 for good help.

Now comes an excerpt with **passives indicated in bold** and active verbs underlined to show that both can be used for variety. However, use more active verbs for animation and honesty. I've saved this important point for last - the strong slot! Always remember that passives can be abused or people often misuse them (to illustrate both voices) to cover laziness or imprecision. For example, A scientist might write *"As is well known"* or *"As is widely held,"* when it would be better to say *"I think."*

I strongly recommend flagging lines like *"It is widely assumed"* to make sure that this is true in the literature rather than your own office!

Best wishes in using these three new skills; remember to wear that "sweatsuit" as you write.

Lecture 8

How to Create a Sense of Structure

Successful writing never appears haphazard.

Good writers give their readers a sense of pattern within which to feel secure. That pattern occurs both on the scale of individual sentences and paragraphs (micro) as well as the whole text (macro). But how is that structure built? Today's lecture will offer some techniques, beginning at the micro level, the "trees" before the "forest."

Writers wanting to improve their structural skills have a great advantage in Italy. Of particular inspiration is Rome, where civil engineers and designers created imperial structures of amazing permanence like the Colosseum, triumphal arches, and the Pantheon. The eye is also gladdened by Rome's baroque architecture like the work of Bernini at Palazzo Odescalchi or Borromini on Palazzo di Propaganda Fide. The secrets common to such marvelous buildings are also those of well-crafted writing: repetition and variation. Recall that entablature above columns will alternate straight and arched sections, that the Colosseum rests upon one layer of Doric columns which in turn support Ionic which are capped by Corinthian, suggesting as well the socially divided "orders" seated within the whole. Consider the regular variation of convexity and concavity in the bays and cornices of baroque works by the architects of the 17th century. In all these cases controlled repetition and variation tell spectators that an architect has arranged space deliberately.

Writers convey that same sense of deliberation through interrelated sounds and syntactic parallels that link concepts in the reader's mind. Think of these techniques as the architecture of sentences.

Skill One: Using sound to create structure

Here is an example of sound used well to link related thoughts. It comes from a negative review by Patricia Cohen of a non-fiction book (IHT, February 5, 2003), but it could be a reviewer's comments on a scientific article. The two sentences are 20 other sentences apart in the original.

1. *"But if the authors have failed to say what it all means, they have also failed to make the case that it all matters*

   And here is the concluding sentence with its structural echo:

2. *"What they haven't done is show how it is significant in ways that matter."*

This highly critical dismissal says the authors have only assembled data. They have not properly discussed and interpreted their evidence; if the text were scientific, its discussion and conclusion sections would be written off as weak. What makes this review memorable is that meaning is highlighted by repeated or rhythmic sound. You might object that only poets worry about sound, that scientific prose need not be poetic. But I will answer that sound is always every writer's friend. Sound is like placement and punctuation in directing the reader's attention.

In sentence one above, for example, the author has linked the key concepts of failure in interpretation (saying what it means overall) and failure in argument (that it is connected to other ideas in a larger sense, *"it all matters"*) by repeating initial sounds (f, a, and m) and those within words as well (a's). She does the same in sentence two where the failure of argument is underscored by the repeated s's and w's as well as the repeated a sounds inside *"what," "haven't,"* and *"ways that matter."* Note especially that she gives the sense of an ending, a very important part of structuring, by repeating the word "matter" in sentence two and ending on it.

Linking the first sounds of related words is called "alliteration" and linking interior vowels is called "assonance."

But all you really need to know is that it conveys meaning in a memorable way: that is why ancient scientists used rhyme to link related ideas in lecturing students. This sophisticated skill is one you can learn by reading your drafts out loud and listening carefully to different options. Study work by writers you admire to find other examples of alliteration and assonance. And you'll be glad to know that using sound to link ideas in the reader's mind works well in every language!

The converse of our example is also true: if using sounds well pleases grateful readers, using ugly sounds repels them. Read aloud to catch such sounds. Be careful of back formation, turning nouns into verbs by adding 'ize." I just edited a management paper using the infinitive "to untangibilize." This horrible neologism apparently means "to make some concrete thing virtual." I would say that to get around the sound and oddity of "untangibilize." In general, if a group of sounds is hard to read out loud, change it. For example, say, *"Apennine seismic array"* to avoid the mouthful of *"Apennines seismic array."* Remember that studies of readers show that they hear "in the mind's ear" what they read on the page.

Skill Two: Using syntactic parallelism so Form matches Content

Wherever possible, give the reader clues to your logical structure through your syntax. Remember from past lectures that main ideas must therefore go in main clauses and lesser ideas in dependent clauses and on down the grammar hierarchy to prepositional phrases.

Here we'll look at new and more sophisticated techniques. If we go back to Cohen's non-scientific example above, we see that she has put the related thoughts *"failed to say"* and *"failed to make"* in parallel slots (in bold below) before the parallel direct objects, *"what it all means"* and *"the case that it all matters."* (underlined - the second object is just enough different to be interesting):

1. *"But if the authors have **failed to say** what it all means, they have also **failed to make** the case that it all matters."*

   This double pairing format occurs within the arch of an "if-then" logic and is complemented by the careful sound links discussed above. Two important skills in this one small sentence give it structure "to burn" (an American idiom meaning so much of something that part of it can be wasted or thrown away). Readers know they are in the presence of deliberate planning, the composition we strive for.

   Here is another good example of syntax matching logic:

2a. *"For this reason, **assessing** the actual magnitude of the 1909 earthquake, **estimating** its rupture length and the extent of faulting at depth, **understanding** its tectonic and large-scale geodynamic context are all crucial steps towards a more accurate prediction of the ground motion associated with similar future earthquakes."* (47 words)

   The writers have done several things well here. They have used three energetic verbals (shown in bold) in **parallel syntax** to show that all are **equally** important steps. **The reader cannot miss this structural message: the same parts of speech in the same order indicate parallel ideas!** Remember this for outlines and bullet formats too. In other words, if you start the first bullet with a verb, continue that pattern for parallel concepts to give a sense of unity.

   For the example above, I would make only small revisions shown underlined:

2b. *"For this reason, assessing the actual magnitude of the 1909 earthquake, estimating its rupture length and the extent of faulting at depth, and understanding its tectonic and large-scale geodynamic context are crucial steps toward more accurately predicting ground motion from similar future earthquakes."* (43) (even better)

   These minor changes add more energy with the gerund *"predicting"* instead of the abstract noun "prediction" and group the key words more closely. It is also important to flag the last element of a list with the preceding conjunction *"and."* I prefer the American idiom "toward" over the British "towards" here, espe-

cially because the sound is nicer and easier to say with *"steps"*; I also wanted to reserve the *"s"* sounds for linking *"steps,""similar"* and *"earthquakes."*

One important note before leaving this revision. Flagging the last element of a list puts the reader on your thought map and so is very important. If that list already has units with an internal "and," be sure to mark the last element differently. Use "as well as" instead:

"Recent GPS results confirm these orientations in southeastern France and the western Alps as well as the extreme variability of compressional trends within a relatively small region."

Using *"as well as"* tells the reader the structure of your thought; the results confirm two things: orientations and variability. There is no confusion about *"the western Alps"* when the second confirmation is set off by a marker different from *"and."*

One important way to show a unified effect through structure turns upon prepositions and ellipsis. For example, if you want to define directions with respect to one nodal point, use only one *"to"* in the following: *"to the east and west of the macroseismic center."* The first *"to"* works twice or applies to both directions. You elegantly omit *"to the west"* as a clue that the macroseismic center is the node. The effect is tighter and cleaner. Here are more illustrations that I have partly revised:

3. *"Owing to its size and the rapid diffusion of early seismographs…, the event was recorded by several European observatories..."*
If you want to intensify the duality of cause, say: *"Owing both to its size and the rapid diffusion of early seismographs..."*

4. *"...the western part of Provence… is characterized by a compression oriented N-S to NW-SE due to the rotating Italian peninsula and the African-Eurasian convergence."*

Again, if we had kept the second *"to"* before the convergence, the effect would be that convergence is another whole idea. Really you want to stress their unified effect: the compressional direction. One *"to"* unifies rotation and convergence as dual causes. A second benefit of this more elegant ellipsis is cutting down the number of *"to's"* from three in the original to two.

5. *"This observation is consistent with the earthquake's limited size and lack of reported surface breaks."*

As with the preposition *"to"* above, use only one *"with"* if you want to emphasize that consistency is deduced from evidence (limited size and no breaks) as a unified conclusion. The only reason to use a second *"with"* before *"lack"* would be to stress the pieces of evidence, not their unified effect. Consider these different effects of structure when using by also.

Make these same decisions when building relative clauses into lists. Note in the example below: one *"that"* functions for both conclusions to show their logical unity structurally. The conclusions are drawn from the same evidence-the concentrated vertical motions - and one "that" before the list tells us so:

6. *"According to Romieu (1994), however, the main vertical motions observed between 1860-1969 are concentrated around the region of the Lambesc earthquake. This suggests that (1) insignificant regional signals can be removed rather easily, since they induce a constant offset throughout the entire region, and (2) a scenario of major uncertainties in the leveling lines or their processing is very likely."*

In other words, we make structure tell meaning.

As a general rule, remember that readers deduce similarity from things grouped together. Thus, it is wise to use the same construction for things of the same kind. A different construction tells readers to look for distinctions. Here's a simple example with apparently minor differences that change the emphasis.

Note the different but synonymous nouns (underlined) and the either-or construction of the following:

"The data must contain either large survey blunders or processing errors...". This choice stresses that the noise comes in two different types because a separate and different noun is given to each kind and the *"either-or"* conjunctions flag contrast.

Or you might wish to stress the noise itself by dropping the intensifier *"either"* and using only one noun, *"errors"*:

"The data must contain large surveying or processing errors...". Here the writer is less interested in the different types of noise and so draws little attention to them. Because *"surveying"* and *"processing"* are grouped together structurally as paired adjectives, the reader understands them as a unit.

Different structures have different effects! Make them work for you.

Skill Three: Stay consistent so the structure is grounded

One of the most important things to work on is maintaining the order first announced! If you change the order of points introduced in preceding sentences or in the abstract and introduction, you will confuse the reader. In other words, if you start with one structure, stay with it. Don't throw it away! Here is a red example of changing horses in mid-stream:

"The orientation of our model fault is constrained by intensity data and by the focal mechanism tests made on the 3-components of the Goettingen station and the 2-components of the De Bilt Station. The best orientation suggested by the focal mechanism test…is equivalent to that of the western segment of the Trevaresse fold, while the source orientation suggested by macroseismic observations is not accurate enough to clearly resolve between the eastern and western segment. In contrast, the intensity-based epicenter again supports the hypothesis that the earthquake ruptured on the western Trevaresse…"

What I would say is start with the focal mechanism test in this sentence because it gives the good data and interpretation. If you want to match up orientations, start with that. Don't set up a structure of macroseismic data which you then drop. You must stick with the first order given or the reader will be "at loose ends." A reader must never say, "where am I?"

A possible fix might be:

"The orientation of our model fault is best constrained by focal mechanism tests made on… The preferred focal mechanism is consistent with the orientation of the western segment of the Trevaresse fold, but the source orientation suggested by macroseismic observations…is too poor to distinguish between eastern and western segments."

Please note that *"while"* should be used for temporal matters to be precise. In revising the original, I used *"but,"* not *"while,"* to flag a logical turn. Be careful about number: note the problem with *"segment."*

We have been looking at the "trees" of structure but not the overall "forest." I have one general comment to make about "macro" structure: shaping your papers should follow a biofeedback loop of corrections and revisions. Once you make an outline of the whole paper and pick a possible journal, a tentative organization follows. But I urge you to remain flexible. Don't force a permanent organization on your writing in the first drafts of a paper. Microsoft Word makes it possible to move things around! Forcing an organization on your work too soon from laziness or a desire for convenience is as bad as forcing an interpretation on data too soon. Patterns must merge inductively from data and writing!

I counsel trying different ways of organizing your work until you find the best way, not just the quickest! Remember that Einstein said, "Make it simple, but not too simple." Keep reading out loud to check transitions and give your early versions for checking to peer readers. Also allow enough time in between versions to look at

them with objective eyes.

Once you have finished a first draft, go back and read the abstract and introduction. Or go back and rewrite them! I urge putting your assumptions together in the introduction or possibly discussion. Are they explicit and clear?

Make sure that the conclusion is congruent with the beginning and that no early signal has been unfulfilled. Check to see that synonyms link the beginning and end of your paper.

Finally, make sure that you have saved some new information for the conclusion. No paper is deadlier than one that keeps repeating the abstract. A good conclusion indicates the limits of your research and assumptions and suggests further work.

MACRO Skills of Structure: The Big Picture

This section of our lecture is indebted to my husband Dave and friend Peter Bird, both UCLA veterans. This is what I have learned from them, summarized in my lay language:

1. Think about titles as signposts for outlining and writing. Start with a few options and decide what the message will be. Is my paper expressing a theoretical or experimental result? Is it really a review paper? Am I critiquing a model? Or am I synthesizing old ideas to generate new interpretations?

2. What kind of paper do I really want to write? Do I have new data? Do I have new mathematical models for a new theory? Or will I put a new spin on old data?

3. Who is my audience? Once you know your message, you will know which audience can understand or use it. Will my paper be a monograph for a specialized few? Which equations will be best for that audience? And what level of diction will they understand?

4. Once you know the audience, you can guess which journal(s) would be appropriate for them. Can I afford that journal? How long will it take to be published? What length paper do they prefer? How do they handle color figures?

5. How can I respond to the journal's ground rules for figures and tables? What are the word limits for that journal? How should I divide up my information? What lends itself to figures, tables, words? Tables are good for uncertainties, plate names, GPS stations, velocities. How much space would figures take? Would any be redundant? What would be their proper scale? Remember that many readers only look at the abstract and figures.

6. Make sure that words, tables, and figures are congruent. Do my words follow an inductive pattern from the particular to a general rule or a deductive format showing how details fit in? Is there a clear spatial or chronological structure? Don't just throw words at the page!

Such questions become the parameters of writing. If you use them as the pillars and supports of your work, it should be read for years to come.

I will close with architectural photos as my prop. Remember that structure and meaning are one; whether you construct buildings or sentences, form should express content.

Please note that I append here Peter Bird's instructions on structuring a paper and a working outline of a current paper by Dave Jackson.

Some personal views on how to begin writing good scientific papers

by Peter Bird, 1983 & 2001

I. PRACTICE MAKES IT LESS PAINFUL

A. Start early: The best students often submit their first manuscript in their 3rd year of graduate school, and have 1-3 papers published by the time they hit the job market!

B. Plan the paper(s) along with the research; this helps you avoid "fishing expeditions" and "endless tunnels". Will the research you do this week result in one publishable page? One paragraph? If not, *why are you doing it?*

C. Schedule a sufficient block of time exclusively for writing (one day for an abstract; one week for a short paper; one month for a monograph). Then allow 20-200% extra time for procrastination. It's a very rare person who gets anything written in "spare time".

D. Don't sit on a finished paper. The common excuse that the paper is being "polished and perfected" is largely self-delusion, because the paper's most important defects are likely to be in areas which you never considered. Exposing it to reviewers and the public is the fastest way to improve it.

II. A STEP-BY-STEP PROGRAM TO OVERCOME WRITER'S BLOCK:

1. If it is a group project, select the first author. This should be the one who did the most work, not the most famous person. The first author will do 80-90% of the writing and re-writing, and must be treated nicely by co-authors who hope to remain in the citation.

2. Select the journal you are writing for. This helps define length, style, and level of audience sophistication.

3. Read the editor's rules, usually available on-line, or perhaps printed in endpapers of the first (or last) number of each year.

4. Write the title and abstract to define the limits of your topic and your conclusions. Look these over critically; do you have unrelated points to make that should be saved for another paper? Or, is the project basically inconclusive until one more critical study is added?

5. Prepare your figures (usually 1-10), considering how they will look (and how much space they will take) when reduced. Face the tough decision about whether to remove the color, pay for printing the color, or switch to an all-electronic journal. This is a relaxing break, and it saves many words in the text. Remember, everyone will look at your figures, some will read your abstract, and only a very few will read your whole paper.

6. Prepare a subject outline, with the headings and subheadings that will actually be in the paper. In if doubt, use the old standard:

a. Introduction
   - motivation
   - relation to previous work
   - overview of the rest of your paper

b. Describe samples/data/field area BRIEFLY

c. Describe experimental/theoretical/observational methods BRIEFLY

d. Discussion
   - (if experiment didn't work, admit it)
   - any lengthy but logical arguments needed to nail down your firmest conclusions
   -clearly-labeled speculations that you haven't proven

e. Conclusions: Omitting speculations, restate your firm conclusions with any qualifying phrases necessary to keep them from embarrassing you two years from now.

f. Acknowledgements: Thank anyone who went "beyond the call of duty" for you, but didn't quite make the author list. By custom, support staff and relatives are omitted. Definitely thank anyone at another institution who contributed unpublished data. Mention of your funding source is mandatory.

7. Convert your subject outline to a sentence outline (all complete sentences). This forces you to make decisions

about what you will actually say before you get tangled up in your own words.

8. Set an overall length limit for your text (allowing journal space for abstract, figures, tables, and references), and then break it down to allocate words (or manuscript pages) per sentence of your outline.

9. Now, finally, begin writing the text; all you have to do is flesh out each topic sentence with supporting detail and/or references and logic until your budget tells you to stop. For diversion, *chase down each reference* as soon as you use it, and get the complete citation into your personal bibliographic data base (like *Reference Manager*™) with some brief notes. Don't ever copy references second-hand without checking them! (They might be actually be 5th-hand; who knows where that idea has been?)

10. Edit fiercely:
All first drafts contain vague and redundant phrases.
Passive voice is inappropriate in most introductions, discussions, and conclusions, because it is important to be clear about how your (educated) opinions differ from those of others.
Criticism of competitors should be as impersonal, mild, and subtle as you can devise.

11. Ask a knowledgeable colleague to identify unclear arguments or details.

12. Rewrite the title and abstract to better reflect the final product, and insert as many "keywords" as necessary to catch the eyes of indexers and random readers.

III. READ LOTS OF SCIENTIFIC PAPERS

Earthquake size and fault dimensions
Anna E. Holt and David D. Jackson

Abstract
Introduction
Review
- Regression relationships
- Wells and Coppersmith
- Uses of
- Questions asked about Magnitude and Fault Dimension
  - Depends on strike slip, normal, thrust?
  - Depends on regional tectonics?
  - Depends on region?
  - How to measure L? Segments?
- Our question: Is fault length equal to rupture length?

Methods
- Data selection
- Earthquake data
- Fault maps

Results
- No correlations between m and PL
- No correlation between PL and RL, SL, or RA
- 5/14 did not stop at end

Discussion
- Implications for Hazard estimates
- Wells and Coppersmith doesn't work for mx
- Negative prospects for characteristic earthquakes
- mx must be larger than given by W&C
- How to estimate mx?
- Regional moment balance, generic values
- Maybe concept needs replacement; talk about 1000 year event instead

Increasing mx may actually decrease hazard
Show F vs mag for diff mx, same MomRat
Why don't we see big earthquakes?
We don't look
They are rare; expectations depends more on a-value than on mx.
Earthquake mechanics
If mapped faults are complete, then quakes frequently make new rupture surface
But fault maps may not be complete
Fractality may mean fault maps are never complete
What good is geology in hazard estimation?

Figures

1. Plot of m vs PL; show m vs SL too from W&C
2. Plot of SL vs PL
3. Fault map before and after
4. Magnitude distributions for different mx values

Tables

1. Fault parameters (WC) and Prior Length

Constraints:

Bull. Seis. Soc. Amer. (because W & C published there)
Ten pages, five figures, one table

This kind of "forecast outline" (Kathy's term) is especially useful with papers having multiple authors. It helps them divide up sections for writing and tasks like figure design.

Lecture 9

The Spoken Word and Revision Review

For our last lecture I will consider "giving an address" or speaking about your work. What makes a successful talk, whether it be a formal paper before a large audience or a poster "chat" before an audience of three?

Let me begin with the first challenge, a formal presentation. I will break it down into suggestions for preparation and then the delivery. My remarks are based upon my own years of teaching but are indebted as well to my husband Dave, veteran of many conferences.

Skill one: Preparing for a formal talk

1. First decide upon the kind of talk you wish to give, dictated by the audience appropriate to it. Decide whom you will reach and whom you will leave behind. Will your remarks be directed to:

   a. *experts only*? If then, the talk should be rich in technical detail. It should have particularity and depth that only a knowledgeable elite can grasp. In this context, you can assume that the audience will already know why your work is important. This talk would be abstruse and dull for all others because it defines fewer terms and is narrow in scope.

   b. *interested others not expert in your particular specialty*? For such a group, you will synthesize past findings as context for your work and trade some depth for breadth. Some definition of terms and explanatory analogies will be needed here. Answering why your work is important is key.

   c. *potential employers or grant givers*? For this group, you must present what is new in your work: your original contribution. Clarify beforehand what is expected, whether your presentation is for a specialized conference or job interview "performance." In Dave's department, for example, prospective job applicants are told what percentage of their talk should be highly technical and what should be for a broader audience.

2. Once you have a draft of your speech written and revised, tape record it. This practice will help you check whether it fits the time allotted. Then play the tape back to check for errors that your eye missed but your ear will catch (use my writing and editing guidelines as a systematic guide as well as our workshop notes). One of the most important parameters to check is sentence length. This is where the one-breath test is key, because listeners need shorter units than readers. *A listener cannot go back and reread as you speak!*

   Fix any mistake you found. Before recording again, underline the thought units of each sentence. Which words go together logically? *Make sure that the pitch of your voice rises slightly in the middle of such units in a gentle arch. Do not add too much pitch variation to each word* as many Italian speakers do; rather think of pitch variation over the whole thought to connect its parts like a musical phrase. Men and deep-voiced women must be especially careful not to drop their pitch and volume too much at the end of units. Although such a drop usefully signals an "end," it must not be overdone. Too many people swallow the last words of a sentence or paragraph. And never take a breath in the middle of a thought unit. It might help you to write an arch over each thought unit and a line where you can breathe, just as singers do. Then record again and play back. This biofeedback loop will help you get used to your own voice speaking English. Better to hear a mistake now than at the conference!

   One special area to listen for is cleanly articulated consonants, especially at the beginning and end of words. English is a song of consonants; Italian a song of vowels. Think for example of how the city Zurich beco-

mes "Zurigo" in Italian. If your consonants are unclear, no native speaker will understand you. Exaggerate the key consonants! Be sure not to add any shadow vowels after the last consonant of a word - no "a" or "e" sounds to make it sound more beautiful, more Italian. Remember that English is a very Germanic language. Think consonants and think articulation.

Once you are satisfied with the tape recording loops, practice giving your talk before colleagues. If you can find any native English speakers to play audience, treasure them and their comments! Have your listeners raise their hands to indicate where you should slow down, or articulate more cleanly. Encourage them to question you so that you become comfortable with thinking on your feet. Try practicing at the same time as your time slot at the conference so you imitate the alertness needed for the real occasion.

Speaking more slowly than usual will help clean up your pronunciation and is a special gift to listeners who are new to your ideas. Check for this key recommendation as you tape record your paper.

3. Check that your figures and tables are color-coded and large enough to be legible. Show them to colleagues in your practice talk. Get their feedback. Are the visuals too detailed? Are they clear and interesting? Do they omit any salient points?

Skill Two: Giving a Formal Talk

Don't "reinvent the wheel." Imitate the skills of teachers and public speakers you have admired and enjoyed before. What did they do to keep you interested as they gracefully taught you? To those memories, I add some suggestions:

1. Remember that talks are "teaching moments" which sink in when you maintain eye contact with your "students," the audience. Move around some, smile, speak with some energy and changes in pitch. Some humor will enliven the presentation (see for example the funny AGU appendix on "terrible talks" provided by Dave Jackson.)

2. Remember, however, that interest without clarity is a bird with one wing. Make sure that you give a brief outline of your speech at the beginning, as in *"This presentation will have three parts devoted to…"* That indication will give the audience a road map for information new to them.

3. Remember to start more slowly so that people unfamiliar with your accent or pronunciation can *decode it*. David Harte (a New Zealander) and my American David both suggest reading your title and maybe a sentence of your abstract out loud to give the audience a chance of matching your sound to the visible text. Even native English speakers from the Commonwealth nations and others sound very different and use different idioms and slang (see helpful and funny article 2 in the appendix). Add to that *your* wonderfully accented English and you have a confusing "brew."

4. Remember not to add an extra syllable in pronouncing "ed" past participles like "changed" or "processed." In most cases that "e" is silent so "changed" would be one syllable only and "processed" would be two, not three. Most Italians see a vowel and "run with it" since all letters are meaningful in Italian. This is not true in English spelling. Some two-syllable exceptions to this rule are "a learned professor" or "a blessed saint" when the past participle is used as an *adjective*. Those words are only one syllable, however, when used as *verbs or in verb phrases*. Practice this rule when tape recording yourself because the "ed" mistake will distract and confuse English listeners. Also try to avoid the wonderful Italian interjection, "no" as a conversational ornament. It is not idiomatic in English.

5. Remember to specify your policy on questions at the beginning. Do you want them all held till the end? Will you accept substantive ones during your presentation? Sometimes a tangential question will derail you; be sure to take control of your own talk. Don't let the questioner take over too many of your minutes. Answer briefly and get back to what *you want to say*. However, questions do add good rhythm to a pre-

sentation; they are not the enemy. Turn every question to what you best know but if you don't know the answer, admit it and suggest some other references where it might be found.

6. Allow time for things to go wrong. Bring back-up discs. Be sure to bring preprints and business cards!

7. And in the strong last slot, remember tact. Try to be objective rather than condescending and dismissive of work with which you disagree. Here's an emotionally weighted example by a political advisor hired to put the right "spin" on things. He is praising a new Senate majority leader with the format: "not that" but a "wonderful this."

   "Instead of the transactional politics of just getting things done, it's the politics of passion." (Mitch Bainwol, quoted in IHT, March 14, 2003). Note the dismissive, ridiculing *"just"* and the strong slot for the alliterative, catchy *"politics of passion"* that replaces mere *"transactional"* behavior.

   Avoid such emotionally loaded words and formats unless you really mean them. If you don't want to insult work that you find misguided, say that *"Scientist A finds…, but Scientist B holds..."*. A more dismissive structure is *"Although Scientist A maintains…, I conclude…"* The *"although"* is a somewhat reductive qualifier.

Skill Three: Giving a Poster Talk

Poster presentations are quite different from formal talks since you will have no stable audience. Your findings must catch passersby visually within a radius of about five meters. Here is a recipe for "catchiness:"

1. Concision counts! A poster is a distilled paper. Don't put an entire published paper on the poster. Instead bring preprints and/or short handouts for those most interested.

2. Use questions in the title and statement of the problem. Use a bullet form, especially for your conclusions. To see if it is worth stopping, most people will first skim your title and conclusions so they are key.

3. Listen carefully to whatever is unclear or unanswered for questioners. This will be valuable input in revising future related work.

4. Points 1-7 above are relevant to poster presentations also.

Before moving on to some revision practice together, I have a "graduation message" for you. Enjoy your progress in writing and speaking scientific English.

Don't be discouraged! Practice one skill at a time and you will find that writing/rewriting with more rigor will improve your critical thinking as a whole. One cannot write well unless one thinks well, so improving one's writing is very good "medicine" for any scientist. Below is some humorous "sugar" to make that medicine go down.

U.S and Britain: Divided by a common language

Shashi Tharoor
International Herald Tribune, Thursday, March 13, 2003

NEW YORK. An English friend of mine says that he nearly had a heart attack on a flight in the United States when the American pilot announced that the plane would be airborne "momentarily."

In British English, the language my friend speaks, "momentarily" means "for a moment," and he thought the pilot was suggesting an imminent crash soon after takeoff. In American English, however, "momentarily" means "in a moment," and the pilot was merely appeasing the impatient passengers.

The plane took off, stayed aloft, my friend's heart stopped thudding, and he lived to tell the tale. But he understood better than ever before the old adage that Britain and the United States are two countries divided by a common language.

Anecdotes abound about the misunderstandings that arise when foreigners come to the United States thinking that they know the language.

In one anecdote, a young man, in the course of a passionate courtship, tells his American girlfriend, "I'll give you a ring tomorrow." All he meant was that he would call her by telephone. But she understood him to have offered betrothal, and the relationship didn't survive the misunderstanding.

Then there's the hotel that failed to understand an English guest who called to say he had left his "trousers in the wardrobe." Translators had to be summoned before the hotel staff finally cottoned on: "Oh, you've left your pants in the closet. Why didn't you say so in the first place?"

Sometimes you can get the right word but the wrong concept. India's former foreign minister, M. C. Chagla, once ruefully recounted the time he wanted to order a modest bite from room service in a New York hotel and requested sandwiches.

"How many do you want?" Chagla was asked. Imagining delicate little triangles of thinly-sliced bread, he replied: "Oh, half-a-dozen should be enough." Six sandwiches duly arrived, each about a foot long (30 centimeters) and four inches high.

In my first week on a U.S. university campus, I asked an American where I could post a letter to my parents. "There's a bulletin board at the Student Center," he replied, "but are you sure you want to post something so personal?" I soon learned that I needed to "mail" letters, not "post" them (even though in the United States you mail them at the "post office").

In Britain, one concludes a restaurant meal by asking for the bill, and conceivably paying by cheque; in America, one asks for the check and pays with bills.

The language of politics is also not exempt from the politics of language.

When a member of Parliament in Britain "tables" a resolution, he puts it forward for debate and passage; when an American Congressman tables a resolution, he kills it off.

A "moot" point is one the Englishman wants to argue; but if it's moot, the American considers it null and void. Such differences of usage reveal something of the nature of American society.

It is no wonder, after all, that while the British "stand" for election, Americans "run" for office.

U.S. statesmen from Alexander Haig to Donald Rumsfeld have delighted global audiences with their own variants of the Queen's tongue. The American form is usually the more vigorous, and American usage stretches the possibility of the language in more inventive ways.
A British linguist once told a New York audience that whereas a double negative could make a positive, there was no language in the world in which a double positive made a negative. A heckler put paid to his thesis in forthright American: "Yeah, right."

Yeah, right, indeed. With the universality of English largely a result of U.S. global dominance, it's time for other English speakers to stop quibbling about whether the American usage is right or wrong. It simply is.

And as the Americans have taught the rest of us to say: that's O.K. Though not even they can tell us what those two initials are meant to represent. The writer grapples regularly with the differences between British English and American English, both as a novelist and as undersecretary-general for communications and public information at the United Nations. This is a personal comment.

Guidelines for Giving a Truly Terrible Talk (Copyright American Geophysical Union)

Strict adherence to the following time-tested guidelines will ensure that both you and your work remain obscure and will guarantee an audience of minimum size at your next talk. Continuity of effort may result in being awarded the coveted 5:00 P.M. speaking time on the last day of the next AGU meeting.

Slides

Use lots of slides. A rule of thumb is one slide for each 10 seconds of time allotted for your talk. If you don't have enough, borrow the rest from the previous speaker, or cycle back and forth between slides.
Put as much information on each slide as possible. Graphs with a dozen or so crossing lines, tables with at least 100 entries, and maps with 20 or 30 units are especially effective; but equations, particularly if they contain at least 15 terms and 20 variables, are almost as good. A high density of detailed and marginally relevant data usually preempts penetrating questions from the audience.
Use small print. Anyone who has not had the foresight to either sit in the front row or bring a set of binoculars is probably not smart enough to understand your talk anyway.
Use figures and tables directly from publications. They will help you accomplish goals 2 and 3 above and minimize the amount of preparations for the talk. If you haven't published the work, use illustrations from an old publication. Only a few people in the audience will notice anyway.
Make sure at least one slide is in upside down or sideways. This relieves tension in the room.

Presentation

Don't organize your talk in advance. It is usually best not to even think about it until your name has been announced by the session chair. Above all, don't write the talk out, for it may fall into enemy hands.
Never, ever, rehearse, even briefly. Talks are best when they arise spontaneously and in random order. Leave it as an exercise for the listener to assemble your thoughts properly and make some sense out of what you say.
Discuss each slide in complete detail, especially those parts irrelevant to the main points of your talk. If you suspect that there is anyone in the audience who is not asleep, return to a previous slide and discuss it again.
Face the projection screen, mumble, and talk as fast as possible, especially while making important points. An alternate strategy is to speak very slowly, leave every other sentence uncompleted, and punctuate each thought with "ahhh," "unhh," or something equally informative.
Wave the light pointer around the room, or at least move the beam rapidly about the slide image in small circles. If this is done properly, it will make 50% of the people in the front three rows (and those with binoculars) sick.
Use up all of your allotted time and at least half, if not all, of the next speaker's. This avoids foolish and annoying questions and forces the chairman to ride herd on the following speakers. Remember, the rest of the speakers don't have anything important to say anyway. If they had, they would have been assigned times earlier than yours.

Coordinamento editoriale e impaginazione
Centro Editoriale Nazionale | INGV

Progetto grafico e redazionale
Laboratorio Grafica e Immagini | INGV Roma

Via di Vigna Murata, 605
00143 Roma
Tel. +39 06518601 Fax +39 065041181

http://www.ingv.it

Istituto Nazionale di Geofisica e Vulcanologia