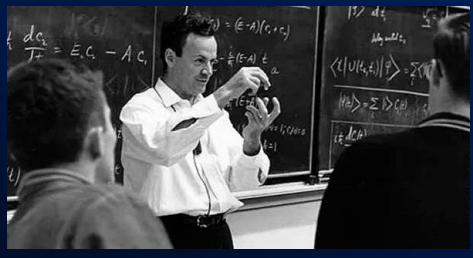
The Quantum Principles of Academic Writing

HOI F. CHEU



"Physics **is** to mathematics what sex **is** to masturbation."
Richard Feynman

"Science writing is to literature what prostitution is to celibacy."
Hoi Cheu

"The Learned Public":

- Communicating Science to the academic community at large;
- Non-Physicist Scientific Audience/Readers (e.g. International Conference on Tumor & Cancer Immunology and Pediatric-Oncology);
- Grand Application Committees (e.g. Tricouncil funding);
- Your thesis supervising committee;
- Specialist journal editors, reviewers and readers.

What are you talking about?

(1) If you are not writing to yourself, you are writing to the "public."

(2) Don't dumb down the science; instead, bring up the audience.

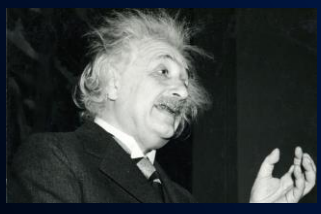
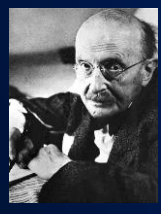
(3) Your audience may "know more" than you do, but they do not know what you are thinking.

The First Principle

$$E = hf$$

Photon Energy = Planck's Constant x Wave Frequency

Max Karl Ernst Ludwig Planck


$$E = \ldots MC^2 = hf = \hbar\omega$$

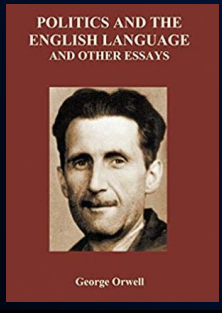
$E = hf$

Effectiveness = Hoi's Constant x Frequency of Practice

Hoi's Constant:

Take all the principles into account, and break any one of them before writing anything outright barbarous.

Derived from George Orwell's "Politics and the English Language"



Duality

- Refer to exact technical and academic terms.
- Use spoken language and common words.

Both are true!

This principle comes from Pulitzer winning novelist Cormac McCarthy. McCarthy has worked as a copy editor for Physicist Lisa Randall at Harvard University.

Full listing:
<https://www.nature.com/articles/d41586-019-02918-5>

"Short words are best, and old words when short, are best of all." Winston Churchill
"Never use a long word where a short one will do." George Orwell

LATIN (SCHOLARLY) WORDS:	ANGLO-SAXON (SHORT) WORDS:
demonstrate	show
investigate	look into
utilize	use
postulate	suppose
commence	begin
expeditiously	fast, quickly
fallacious	false
incandescent	bright

WHAT'S THE SHORT WORD?

- adhere
- terminate
- subsequent
- spatial and temporal
- pedological subjects
- Hamiltonian operator

- stick
- end, stop
- next
- in space and time
- soil samples
- all the mojo and oomph

(just kidding!) $\widehat{H}$ has no Anglo-Saxon substitute.)

EXAMPLE

Although investigations of medieval plague victims have identified *Yersinia pestis* as the putative etiologic agent of the pandemic, methodological limitations have prevented large-scale genomic investigations to evaluate the development of the pathogen's virulence over time.

By studying medieval plague victims, we learn that *Yersinia pestis* likely caused the Black Death; however, we do not know how the infection of the bacteria changed over time, because large-scale genomic analysis is hard to do.

A Useful Trick

Read it aloud when you are editing.

Another Duality

- Use of a variety of words and sentence structures can keep things interesting.
- Consistent usage of terms and simple sentences can improve clarity.

Both are true!

In relatively unproductive ecosystems like deserts, grazers are so rare as to be negligible, and competition for resources structures plant communities. In more productive systems like grasslands, a large effective herbivore community can be supported and grazing determines plant biomass.

Entanglement

When ideas and concepts are convoluted, break down the ideas into smaller units and explain in simpler sentences. One useful technique is "entanglement."

Parallelism is one technique of entanglement; keeping the subject constant is another.

In relatively unproductive ecosystems like deserts, grazers are so rare as to be negligible, and competition for resources structures plant communities. In more productive systems like grasslands, a large effective herbivore community can be supported and grazing determines plant biomass.

(40 words, 91 syllables, 1:2.3)

In poorer ecosystems like deserts and grazers, **plant biomass** is limited by the competition for resources. In richer ecosystems like grasslands, **plant biomass** is controlled by herbivores.

(27 words, 51 syllables, 1:1.9)

This example comes from *Writing Science in Plain English* by Anne Greene (University of Chicago Press, 2013), p.33; the solution is by Hoi.

Use a variety of verbs; keep the subject consistent.

E.g. Marie Curie says…

She states
She assumes
She asks
She explains
She remarks
She suggests
She reports
She adds
She finds
She interprets

She insists
She assures
She explores
She reveals
She determines
She agrees
She rejects
She proves
She disproves
She concludes

MME CURIE AND HER DAUGHTER IRÈNE, 1925

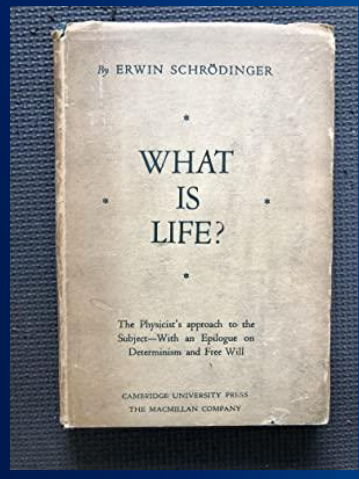
Important:
Do not use the first and second person pronouns.

- Stay away from "I think," "I feel," "we think," or "we feel."
- Avoid "you" if possible when writing a thesis.
- Discuss the subject directly.

Important:
Use first person pronouns to distinguish your work from others

I have mentioned this technical definition [of entropy] simply in order to remove entropy from the atmosphere of hazy mystery that frequently veils it. Much more important for us here is the bearing on the statistical concept of order and disorder, a connection that was revealed by the investigations of Boltzmann and Gibbs in statistical physics.

from Erwin Schrödinger's *What Is Life?*



Important:
Use first person pronouns to distinguish your work from others

The levels of radioactivity of the polyethylene tube samples have to be measured. (O.K. if it is a report within your group)

I have measured the levels of radioactivity of the polyethylene tube samples. (You can say "I" if it is your thesis project)

In academic writing, it is vital to identify whose idea or theory it is.

When naming other people's ideas, you give credit to those who laid the foundation of your research; when you identify yourself, you take responsibility for your thoughts, works, analyses, and findings.

Spin

To keep the momentum going, good writers need to spin the subject-matter, to breathe life into the materials.

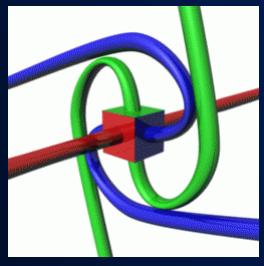


Illustration by Jason Hise

Writing is not just about relaying relevant information.
The strategy and style of presentation count.

Entertainment vs. Excitement

Academic writing should not "spice things up" for "entertainment." But there should still be a "story."

Excitement comes from the study itself:

What is the study? How does it come about?

How does the study work?

What do we learn? What are the limits of the results?

What is the implication? How does it fit into the bigger question(s)?

What is next?

Schrödinger's cat

- The cat is simultaneously both alive and dead *in the sealed box*.
- It is the writer's job to open the box: i.e. to put everything in context.

From Albert Einstein's *The General Theory of Relativity* (1916)

According to Newton's law of motion, we have

(Force) = (inertial mass) x (acceleration),

where the "inertial mass" is a characteristic constant of the accelerated body.

If now gravitation is the cause of the acceleration, we then have

(Force) = (gravitational mass) x (intensity of the gravitational field),

where the "gravitational mass" is likewise a characteristic constant for the body.

From these two relations follows:

(acceleration) = (gravitational mass/inertial mass) x (intensity of the gravitational field)

If now, as we find from experience, the acceleration is to be independent of the nature and the condition of the body and always be the same for a given gravitational field, then the ratio of the gravitation to the inertial mass must likewise be the same for all bodies…. We then have the following law: The *gravitational* mass of a body is equal to its *inertial* law.

It is true that this important law had hitherto been recorded in mechanics, but it had not been *interpreted*.

The Case of the Uncertainty Principle

"It is impossible to simultaneously determine both the position and the momentum of a particle with arbitrarily great precision.... To detect a particle, the detector must *interact* with it, and this interaction unavoidably changes the state of motion of the particle, introducing uncertainty about its original state."

Sears and Zemansky's University Physics 13th Edition, p. 1279.

What is "arbitrarily great precision"?
Can we blame the students for not reading the textbook?

The Uncertainty Principle:

The product of the uncertainty in position of a particle and the uncertainty in its momentum can never be less than one-half of the reduced Planck constant:

$$\Delta x \, \Delta p \geq \hbar/2$$

UBC Open Text,
University Physics Volume 3

A detailed explanation

This is the way Heisenberg stated the uncertainty principle originally: If you make the measurement on any object, and you can determine the x-component of its momentum with an uncertainty Δp, you cannot, at the same time, know its x-position more accurately than $\Delta x \geq \hbar/2\Delta p$, where $\hbar$ is a definite fixed number given by nature. It is called the "reduced Planck constant," and is approximately 1.05×10^{-34} joule-seconds. The uncertainties in the position and momentum of a particle at any instant must have their product greater than or equal to half the reduced Planck constant.

Hoi's Note:
Planck constant is $6.62607015 \times 10^{-34}$ J-s; for calculations in radian, the constant is divided by 2π, which makes the reduced Planck constant.

This is a special case of the uncertainty principle that was stated more generally: the more general statement was that one cannot design equipment in any way to determine which of two alternatives is taken, without, at the same time, destroying the pattern of interference…

[two long paragraphs to show an experiment].

THE SPIN

The Uncertainty Principle "protects" quantum mechanics. Heisenberg recognized that if it were possible to measure the momentum and the position simultaneously with a greater accuracy, quantum mechanics would collapse. So he proposed that it must be impossible. Then people sat down and tried to figure out ways of doing it, and nobody could figure out a way to measure the position and the momentum of anything – a screen, an electron, a billiard ball, anything – with any greater accuracy. Quantum mechanics maintains its perilous but still correct existence.

Richard Feynman, *The Feynman Lectures on Physics*, The New Millennium Edition, Vol. 3, 1-8.

Richard Feynman's spin tells a story to inspire the students to advance science.

Hoi's Uncertainty Principle of Writing

$$\Delta x \, \Delta p \geq \hbar/2$$

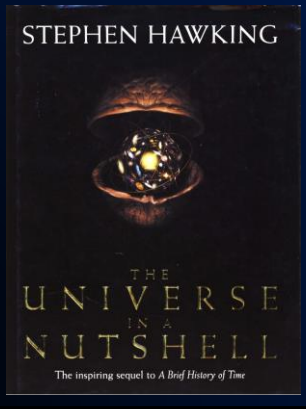
Conciseness x Precision ≥ Hoi's constant/2

It is not possible to say everything precisely and concisely at the same time. To be precise, the writer must take the time to explain, and as a result, compromising brevity. To be concise, on the other hand, the writer can only go so far, and as a result, compromising precision.

If it were possible to write precisely and concisely at the same time, then the English department would collapse. Now scientists are sitting down and trying to figure out ways of doing it.

"One can never be exactly sure of both the position and the velocity of a particle. The more accurately one knows the one, the less accurately one can know the other."

Stephen Hawking, *The Universe in a Nutshell*, p. 208.



How to judge what Is important?

- Ask yourself what your readers need to know
- Think about what you need to complete your story

These rules seem contradictory, but they are all true:

Academic Drives	Reader's Needs
Be precise	Be concise
Get to the point and go deep	Take it easy and explain
Technical terms and equations are exact	Common words are easier to understand.
Relay relevant information	Deliver excitement and challenge
Find out your part of the solution	**The Whole Story**

Effectiveness = Hoi's Constant x Frequency of Practice

Like using differential equations in quantum mechanics, working around these writing rules requires practice; the more you practice, the better choices you make.