

you need to do more. Make your ideas connect so tightly that we can't get lost. By linking stress and topic, resolution and opening, you can tie together sentences and paragraphs and make the sweep of your arguments compelling. You can make your papers and proposals page turners.

## EXERCISES

### 13.1. Evaluate published papers

Pick two of the papers you've been evaluating: one that reads well and smoothly and one that doesn't. Evaluate how each manages the flow of ideas between sentences and between paragraphs. Do they use the techniques discussed in this chapter to develop flow? If they don't are there places where you could rewrite them to enhance the flow and ease the writing?

### 13.2. Write a short article

Revisit your short article and look to see whether you could enhance the flow of ideas by working more actively on linking your sentences and paragraphs together. If you can, do it.

### 13.3. Edit

#### A. Revise these sentences so the ideas flow smoothly.

Studies comparing iron-resistant and sensitive cell lines confirmed that protein X17 is denatured in the presence of Fe. Protein X17, however, reverts to its native form when cellular Fe concentrations decrease.

#### B. Revise the following paragraphs so that the ideas link clearly.

The TREE2 promoter is upstream of the *tryb* gene. However, Silva et al. (2008) showed that the STEM3 promoter is also upstream of this gene and appeared to be involved in *tryb* regulation. We showed that both are necessary and they interact to further upregulate *tryb*: knocking out TREE2 reduced transcription by 50%, knocking out STEM3 reduced it by 75%, and knocking out both prevented transcription entirely.

When LEA was absent, however, even with both promoters intact, transcription rates were only 50% of control levels. It appears that LEA interacts with TREE2 and STEM3 to induce greater promotion than either can effect on their own.

## Energizing Writing

Don't say the old lady screamed. Bring her on and let her scream.

—MARK TWAIN

Good stories are driven by action. But the drive comes from seeing and feeling it; the old lady has to come on stage and scream—no disembodied howls in the distance. Writers condense that idea to the mantra of “show, don't tell.” In science writing, the two C's of SUCCES—credible and concrete—both emerge from showing. We *show* the reader our data, and we *show* them our logic. Isn't the phrase “data not shown” always a little suspect?

Within a sentence, showing action is the job of verbs and it's an important job. Good writers use their verbs well, imbuing their papers with life. Bad writers use them poorly, stealing energy from the story, leaving it dull and listless. While bureaucrats are the grand masters of turgid text, some scientists compete with them for the title. There are many ways to overburden your writing, including three notable ways to emasculate your verbs: (1) passive voice, (2) fuzzy verbs, and (3) nominalizations.

## 14.1. ACTIVE VERSUS PASSIVE VOICE

The simplest structure for any story is straight OCAR, which gives the reader information in the sequence that they can most easily process: who did it (O), what they did (A), and what happened (R). The sentence structure that most directly matches OCAR is as follows.

John	called	Jane
Actor	Action	Acted-on
Subject	Verb	Object

This is the active voice. It is clear, concise, and direct. It is also visual and evocative. You can see the actors because they are named up front, and you can visualize the action because it is carried in a verb that immediately follows the subject. Hence, Strunk and White's commandment: "Use the active voice."

Sometimes, though, we don't want to tell a story about the actor but about the acted-on; we want to talk about Jane, not John.

Jane	was called	by John
Acted-on	Action	Actor
Subject	Verb	Object

This is the passive voice. To create it, we make the acted-on the sentence's subject and make the verb by coupling some form of "to be" to the action verb; in this case, "was called." The passive voice is a powerful tool. It allows you to control who or what, in a sentence, the story is about. It allows you to select the grammatical subject and object of the *sentence* relative to the actor and acted-on of the *story*. It allows you to control what goes in the topic and what goes in the stress. And it does all that without changing the action. Whether you write "John called Jane" or "Jane was called by John," John still made the call. Only our perspective has changed.

But the passive voice carries a price: it weakens the story structure. "With an active verb, the subject of the sentence is doing something. With a passive verb, something is being done to the subject of the sentence. The subject is just letting it happen" (Stephen King, "On Writing").

Without an actor front and center, action is intangible. All we can do is say the old lady screamed; in the passive, we leave her off stage.

## 14.1.1. Controlling Perspective

Because the passive voice is weaker storytelling than the active, we should avoid it as a matter of course, but it has several good uses. The first is in controlling perspective: who the sentence is about. Being able to shift a sentence's topic between actor and acted-on is critical for developing effective story arcs and flow, as I discussed in chapter 13 and illustrated in example 13.3. There I rewrote the transitional sentence to start with a passive expression:

*"In salvage logging, trees that have been attacked are selectively harvested. The dead trees that are harvested, however, can provide cavities that are nesting sites for birds."*

That created a single entity that was the subject for a larger, active voice sentence. Often though, you may need to write the entire sentence in the passive voice to get the appropriate subject up front, as illustrated by the following sentence pairs.

## Example 14.1

Active: A magnetospheric source produces variable electric fields.

Passive: Variable electric fields *are produced* by a magnetospheric source.

## Example 14.2

Active: Soil porosity influences water retention.

Passive: Water retention in soil *is influenced* by porosity.

In each case, if this were the entire story, the active voice version would be better—a stronger message and a shorter sentence. But if we are telling a story about variable electric fields or water retention in soil, the passive would put the right term in the right place and so would be the voice to choose. In allowing you to shift perspective this way, the passive voice shines. It's a tool that weakens a single sentence, but in a way that can allow it to fit more snugly into a paragraph, strengthening the whole.

## 14.1.2. Hiding the Actor

The strength of the active voice is that it forces you to make the actor and action clear. The weakness of the active voice is that it forces you to make the actor and action clear. Sometimes, we don't want to or need to name the actor. The passive voice can do this. The classic example is "mistakes were made," which is used frequently by politicians and bureaucrats to dampen the intensity of the action and dodge blame. Converting "mistakes were made" to the active voice requires putting an actor up front—identifying who screwed up.

Being able to leave the actor off stage, however, is useful for solving a variety of writing problems. For example, even in Materials and Methods sections it has

become generally acceptable to use first-person active voice, for example, "We collected samples." That is fine when it's true. However, in a paper, "we" means the authors. What do you say if there were technicians or interns who helped with the work but aren't coauthors? I know some projects where dozens of people contributed to sample and data collection, and the authors may not even know who specifically collected which samples! Using the passive allows the author to cleanly and honestly tell us what we need to know: samples were collected.

We also use the passive to refer to work when the specific attribution isn't important. For example, I wrote a paper once evaluating when the composition of soil microbial communities affects ecosystem processes such as plant litter decomposition.

#### Example 14.3

It has been argued that such processes should be insensitive to microbial community composition (Schimel 1995).<sup>1</sup>

I deliberately wrote that using the passive phrase "It has been argued" because I had made that argument in an earlier paper but my thinking on the subject had evolved. The new paper was modifying the argument to reflect that evolution. If I had used the active voice, I would have had to say "In a previous paper, I argued . . . but now I think I was wrong," which I thought sounded bad, even if changing our thinking is what we are supposed to do. It might have trivialized the point by making it seem that I was having a private debate with myself. In fact, I wasn't; other papers had made similar arguments or reinforced those I made in the first paper. Because the passive voice doesn't specify who or how many people made the argument, I could leave that open. Even citing my earlier paper didn't mean it was the only one to make the argument. Using the passive to say "It has been argued" allowed me to avoid these issues.

For those times that we need to say what happened and not who did it, the passive is an effective tool. However, it was a long-standing tradition that scientists should divorce themselves from the work by describing their actions in the passive voice, as illustrated in example 14.4.

#### Example 14.4

When expression of *Chla* and *Chlb* were compared, similar patterns of transcript abundance were observed in plants at different developmental stages.

Someone did the comparing and observing, and most likely it was the authors. So why not make this clearer by naming the actor and shortening the subject? "When we compared *Chla* and *Chlb* expression, we found similar patterns of transcript abundance in plants at different developmental stages."

1. J. P. Schimel, J. Bennett, and N. Fierer, "Microbial Community Composition and Soil N Cycling: Is There Really a Connection?" In: *Biological Diversity and Function in Soils*, ed. R. D. Bardgett, D. W. Hopkins, and M. B. Usher (Cambridge University Press, 2005), pp. 171–88.

It's possible that this was one of those cases where someone who wasn't an author did the work. More likely, though, the authors were following the passive voice tradition. Why did scholars insist on using the passive? Why ban the more powerful storytelling tool? The argument was grounded in concerns of scientific objectivity, as expressed in this excerpt: "Using the passive voice in scientific writing allows the researcher to stand at a distance from his or her work. By standing at a distance, an unbiased viewpoint is much more likely to be reached. An unbiased viewpoint encourages a world view and an open mind, surely prerequisites for good science."<sup>2</sup>

This is impassioned plea, and it contains some important truths—but some equally important fallacies. It argues that writing in the passive forces you to remain at a distance from your data and be dispassionate and objective about your work. I agree that objectivity is a prerequisite for good science. However, objectivity does not come from how you treat your *writing* but from how you treat your *data*. The idea that by removing ourselves visibly from the writing we remove our prejudices and imperfections is plain wrong. We did the work, and we wrote the words. They are inextricably ours. You can't change that by changing the writing voice.

True objectivity grows from Anne Lamott's advice in chapter 2: listen to your characters. Be attentive to your data and allow the story to flow from them. Once you have done that, tell the story in the clearest, most effective language possible.

It is a principle that all tools in English have their value, including the passive voice. Even Strunk and White moderate their dictum about using the active voice: "This rule does not, of course, mean that the writer should entirely discard the passive voice, which is frequently convenient and sometimes necessary."

As with all tools, you must know their strengths and limitations to make good decisions about when to use them. The passive voice is for when you need to make the acted-on the subject of the sentence or when you have an honest reason to avoid naming the actor. Use it for those jobs. Otherwise, listen to Strunk and White: use the active voice.

## 14.2. FUZZY VERBS

Science writing isn't supposed to use colorful language to evoke image the way fiction does, although it can be more colorful than most of us make it, as illustrated in examples 5.8 and 7.1. We are, however, supposed to be clear, and verbs that show action make writing clear. Verbs that mask the action are weak and can be confusing. Consider the following.

#### Example 14.5

Controls on the expression of homeobox genes have been evaluated in several model systems.

2. S. R. Leather, "The Case for the Passive Voice," *Nature* 381 (1996): 467.

Here the verb is “evaluated;” it’s passive, but that isn’t the problem. The problem is that this tells us something happened—controls on expression were *evaluated*—but what we really want to know is either how they were evaluated or how they differ between organisms.

This sentence is the opening of a paragraph that goes on to tell how controls differ develops into an interesting story. But the opening would be stronger if it identified what that story is going to be: varying patterns of control. An opening sentence that uses an action verb to introduce that would be:

*“Homeobox gene expression is regulated differently among plants, fungi, and animals.”*

Not only does this make the model systems concrete, it uses a stronger verb and has a stronger message—“is regulated differently.” That makes it obvious that the paragraph will discuss how expression varies across these organisms.

The verb is still passive, but the passive allows us to make this sentence about homeobox genes rather than about plants, fungi, and animals. We could turn it around to activate the verb, but that would make it into: “Plants, fungi, and animals regulate homeobox gene expression differently.” This makes the topic the organisms, instead of the genes. It also forces apart the verb and adverb. The original, passive voice version avoided that.

Another example that suffers from a fuzzy verb problem is example 14.6.

#### Example 14.6

Herbivores facilitate the invasion of exotic grasses by mediating competition between exotic and native plants.

The verbs are “facilitate” and “mediate,” but we are likely to ask “what do herbivores *do* to mediate competition?”

*“Herbivores preferentially eat native plants, giving exotic grasses a competitive advantage that allows them to invade.”*

This sentence now uses verbs that show action: “eat,” “give,” and “invade.” It says what the animals physically do; they eat native plants. This allows exotics to invade the gaps created. If this sentence were the opening of a paragraph, it would now effectively introduce the characters (herbivores, native plants, and invading exotic grasses), the actions, and the challenge (how herbivores influence invasion). It even puts the critical action, “invade,” in the stress position to emphasize it.

Fuzzy verbs say that something happened but not what; action verbs show you what (see table 14.1). Action verbs are powerful, concrete storytelling tools. They make your writing more interesting, which is nice, but also clearer, which is vital.

### 14.2.1. Fuzzy Hypotheses

The worst place for a fuzzy verb is in a hypothesis, yet many are wishy-washy and unfalsifiable. I’ve read proposals with hypotheses like the following.

Table 14.1. FUZZY VERBS VERSUS ACTION VERBS

#### Fuzzy Verbs (Weak)

Occur	Facilitate	Conduct	Implement
Affect	Perform		

#### Action Verbs (Strong)

Modify	Increase	React	Accelerate
Accomplish	Decrease	Inhibit	Migrate
Create	Invade	Disrupt	

#### Example 14.7

Microbial community composition is controlled by the chemical nature of plant inputs, water availability, and soil chemistry.

Here the verb is the passive and fuzzy “is controlled,” and this is a truism rather than a falsifiable hypothesis. Is it conceivable that microbial community composition is not controlled by plant inputs, water, and soil chemistry? Fuzzy hypotheses almost guarantee that your proposal will end up on the “do not fund” list. To make a hypothesis compelling, you need to use concrete verbs that make a testable statement. To transform example 14.7, consider an alternative:

*“The chemical nature of plant inputs is the single strongest control on the composition of soil microbial communities and on their distribution across the landscape.”*

This is in the active voice and the verb is simply “is.” It is a declarative statement—the chemical nature of plant inputs either is or is not the single strongest control; we can test that. This version doesn’t ignore other factors, but it puts them in perspective. This was the actual hypothesis of a proposal, a successful one.

I think people use fuzzy verbs when they are afraid that if they make strong statements, someone may challenge them or they may be wrong. If people feel challenged, you have engaged their interest, and that is good. Challenging proposals sometimes get funded; boring ones never do. Also remember, you are a scientist—it is not your job to be right. It is your job to be thoughtful, careful, and analytical; it is your job to challenge your ideas and to try to falsify your hypotheses; it is your job to be open and honest about the uncertainties in your data and conclusions. But if you are doing cutting-edge work, you are not always going to be right.

You may have some aspects of the system right but others wrong; your piece of the system may be counterbalanced by others; you may even have misinterpreted your data. As long as you did it with honesty, integrity, and intellect, you *did* right, even if you *weren't* right.

People must be able to understand your work and how it influences our understanding of nature. Being concrete and challenging may achieve that and move the field forward, regardless of whether you are right. Being nebulous and timid to avoid being wrong ensures that your work will contribute little. As a result, it will likely be rejected or uncited. One of my mentors, a leader in the field, took gleeful delight in tossing out ideas and stirring up the pot; some ideas were brilliant, others off the wall. He left it to others to figure out which were which. The brilliant ideas stuck and motivated new research; the others faded. Being interesting is ultimately more important than being right.

### 14.3. NOMINALIZATIONS

Fuzzy verbs are energy thieves. They steal energy from the action by telling, rather than showing. You can, however, go a step further and kill the action entirely. Using a strong verb, you might say something like the following.

#### Example 14.8

We investigated the effect of elevated CO<sub>2</sub> on plant growth.

Here the action is expressed in a verb, “investigated,” but many would write this sentence as: “We conducted an investigation of the effect of elevated CO<sub>2</sub> on plant growth.” This sentence has a verb—the fuzzy “conducted.” But did you conduct an investigation, a train, or an orchestra? The action is contained in “an investigation,” but that is a noun. This sentence names the action and introduces a new verb that hides it.

This process of turning a verb into a noun is known as creating a nominalization. As a result of using a noun rather than a verb to describe action, example 14.8 lost energy and gained length, but contains no more information. That is all bad, yet using nominalizations, instead of verbs, is a common failing in academic writing. Examples of nominalized verbs are shown in table 14.2.

To illustrate, example 14.9 nominalizes every important action.

#### Example 14.9

Systemic infusion of fetal stem cells appears to be the most practical mode of administration; however, limited migration of cells to the target tissue may act as a constraint on its effectiveness.

The only verbs are “appears,” “to be,” and “act,” which is sad, as there is no shortage of actions: “infuse,” “administer,” “migrate,” “constrain,” and even “target.” We can convert many of those actions to verbs, tightening this sentence:

*“The most practical way to administer fetal stem cells is to infuse them systemically; however, if cells don’t migrate to the target tissue, this will fail.”*

Sometimes forcing the action into a nominalization pushes it out of a critical position in the sentence, as illustrated by example 14.10.

Table 14.2. VERBS AND THEIR NOMINALIZED EQUIVALENTS

Verb	Nominalization
Move	Movement
Differ	Difference
Suggest	Suggestion
Interact	Interaction
Analyze	Analysis
Develop	Development
In some cases, the verb and nominalization almost have the same form	
Influence	A influenced B versus A had an influence on B
Approach	A approached the problem versus A took an approach to the problem
Yield	The reaction yielded a product versus The yield of the reaction was . . .

#### Example 14.10

Although models exist to calculate reaction rates as a function of molecular size, a failure to reproduce the experimental data is often observed.

This combines a nominalization with a passive to create a sentence with the minimum possible punch. The author is making an important point—these models often fail. However, that is nominalized to “a failure.” This pushes the passive verb phrase “is often observed” to the sentence’s stress, and it buries the critical action in the bowels of the sentence: “a failure to reproduce the experimental data.” This would be better if the sentence’s two clauses were effectively linked and if there were an active verb early in the second clause:

*“Although models exist to calculate reaction rates as a function of molecular size, they often fail to reproduce the experimental data.”*

This works. It opens the second clause with the pronoun “they” to tie it back to the models, and then it hits the important point: “they often fail.” This makes good subject–verb connection and puts the verb in the important place—the beginning of the main clause.

Another problem with verb nominalizations is that they are necessarily connected to fuzzy verbs. Because the action is named in the nominalization, and a sentence still needs a verb, it will be weak. Scan your work for nominalizations—there are probably more than you imagined. As a rule, turn them into verbs.

Table 14.3. ADJECTIVE NOMINALIZATIONS

Adjective	Nominalization
Different	Difference
Difficult	Difficulty
Able	Ability
Capable	Capability
Similar	Similarity

### 14.3.1. Adjective Nominalizations

There is another form of nominalization: converting an adjective into a noun. Examples of adjective nominalizations are illustrated in table 14.3.

Nominalizing adjectives also steals color and energy from writing. They leave it heavy and flat. For example, compare the following pair of sentences. Which is stronger?

#### Example 14.11

- The characteristics of this condition are the oxidation of membrane lipids, the denaturation of proteins, and a reduction in growth rates.
- This condition is characterized by oxidized membrane lipids, denatured proteins, and reduced growth rates.

Version A nominalized every adjective: “characteristics,” “oxidation,” “denaturation,” and “reduction.” In contrast, version B makes them all adjectives; the sentence is shorter and sharper.

Sometimes fixing a nominalized adjective can take several steps, as illustrated in example 14.12.

#### Example 14.12

- There was a difference between the reaction rates of treatments X and Y.
- Reaction rates were different between treatments X and Y.
- Reaction rates differed between treatments X and Y.

These all say the same thing with the action contained in some version of the word “differ.” In version A, it’s a nominalization—“difference”—and “was” is the only verb, a weak one. Version B is better, turning it into a real adjective—“different”—but it still uses the weak “were” as the verb. Version C puts the action into the verb “differed,” and as a result it is both the shortest and most vigorous.

### 14.3.2. Why Do Nominalizations Exist?

If nominalizations are so horrible, why do they exist? Certainly, they weren’t invented to clutter language, steal clarity, and make thoughts impenetrable! Naming something makes it concrete. Names hold magic. We use nominalizations to name concepts, which is useful. Could you imagine having to explain these ideas every time you used them?

Taxation without representation  
Gene expression  
Aromatic molecule  
Ecosystem services  
Epigenetics

Naming a concept is powerful because it defines a new schema, but it is also dangerous. It’s dangerous because when you use the name, you assume that the reader knows and understands that schema. If your reader understands that an “aromatic molecule” is a ring with conjugated double bonds, you have effective shorthand for quickly and efficiently communicating a complex chemical concept. If they don’t know the schema, however, and interpret “aromatic molecule” as “perfume,” you can create some interesting miscommunication.

If your reader doesn’t hold the schema, a nominalization becomes jargon—an unclear term that seems designed to exclude noninitiates from the club. With some audiences, you can safely use a nominalization, whereas with others you must define it. For the public, you would need to define “aromatic molecule” and would look arrogant if you didn’t; for a paper in *Organic Chemistry*, on the other hand, you would look silly if you did.

The ability to nonnominalize complex ideas also allows you to write sentences like “The arguments developed above . . .” In this case, “arguments” is a nominalization that encapsulates what may have been paragraphs’ worth of text into a single word. That is powerful.

For a potent use of nominalizations, let’s go back to example 12.1 from Winston Churchill: “until in God’s good time, the New World, with all its power and might, steps forth to the rescue and the liberation of the old.” Churchill put the nominalizations “the rescue” and “the liberation” in the sentence’s stress. He could have made them verbs: “until in God’s good time, the New World, with all its power and might, steps forth to rescue and liberate the old.” This is weaker—the verbs don’t have the same mass and solemnity, and Churchill deliberately left the action



on “steps forth.” He was encouraging the United States to step forth so that Britain wouldn’t need rescue and liberation! Churchill cleverly used a tool to create eloquence. He also used parallelism and repetition (*the rescue* and *the liberation*) to add weight to his message, and drove it in by putting it in the sentence’s stress. Churchill was a master of the English language; he knew when to break the rules, and how to use all the linguistic tools available to him. You might not save the world with your writing, but you might fund your graduate students.

Find the action in your sentences, put it in your verbs, and put them early in their sentences. If you do, your writing will be clear and lively. Sometimes a passive or nominalization will strengthen your writing, and sometimes they are essential. Every time you use them unnecessarily, though, you make your writing heavier and more opaque. A single unnecessary nominalization won’t destroy your writing, but remember it wasn’t the last straw that broke the camel’s back—it was the accumulation of all the straws. Don’t accumulate straws.

## EXERCISES

### 14.1. Analyze published papers

Look at the papers you have been analyzing and read the critical paragraphs that define the opening, action, and resolution. Evaluate the actions and the verbs. Do the authors put the action in their verbs? Do they use active verbs? If not, try rewriting those paragraphs using stronger verbs.

### 14.2. Write a short article

Go back to your short article. Go through it sentence by sentence, noting the actions you describe and the verbs you use. Is every action in an active verb? If not, can you convert them into active verbs? If you choose to leave *any* action as anything but an active verb, justify your choice.

### 14.3. Revise

- A. Increased mobility of predatory nematodes in soil would increase opportunities for ecological interactions and so alter bacterial population dynamics.
- B. Polyaromatic hydrocarbons and polychlorinated biphenyls present enormous challenges in remediation, invoking large financial costs and presenting significant health risks to the workers who face exposure to the compounds.
- C. It was demonstrated that extraction of soils by  $\text{NH}_4\text{Cl}$  caused an enhancement in the recovery of Al relative to an extraction with  $\text{K}_2\text{SO}_4$ .

## Words

In literature, the ambition of the novice is to acquire the literary language; the struggle of the adept is to get rid of it.

—GEORGE BERNARD SHAW

As I said in chapter 11, words are to sentences what atoms are to molecules. They control the chemistry and “voice” of your writing—how it sounds and feels. Some atoms are inherently dense and toxic, like lead. With others, toxicity comes from their specific combination; carbon, hydrogen, and oxygen can produce fresh and fruity aldehydes but with just a slight tweak become rancid acids. So, too, with words. You can poison your writing with toxic words and toxic combinations.

Choosing words is not easy. English has amassed words from many sources, and different words convey different impressions of what you are saying and even of who you are. Just consider “fornicate” and its four-letter synonym, “f---.”

Academics have an almost proverbial fondness for long, heavy words. Some use them because they think it makes writing sound more scholarly or because they want to show off their erudition, as Dennis Dutton, editor of *Philosophy and Literature* once accused the author of a notably convoluted piece of academic writing: “This sentence beats readers into submission and instructs them that they