frontiers FOR YOUNG MINDS

How to Write a Frontiers for Young Minds Article

A Guide for Translating Your Cutting-Edge Research for Younger Audiences

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Writing for younger audiences is certainly a valuable experience, but it can also be intimidating. Though our Young Reviewers can be quite frank with their comments, they provide meaningful feedback that can help you grow as a science communicator. This guide is not meant to tell you how to write your article, but rather provide you with some tools and considerations as you frame your research for your desired audience.

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1 Why write scientific articles for kids and teens?

- The most obvious reason to write science articles for kids may be to create a valuable tool for science education, but providing plain-language summaries of cutting-edge science has benefits that reach far beyond the content of any individual article.
- When kids and teens read difficult texts, their general reading abilities can actually improve [1].
- Some studies have shown that students might actually learn more when they read things that are just above their own reading level [2].
- There is one important caveat: kids and teens are more likely to engage with more difficult texts if they find the subject matter especially interesting [3,4].
- By providing exciting content that kids and teens might not otherwise have access to, these articles can motivate them improve their reading skills while they learn about the newest advances in science.

2 Starting with the basics: What happens while kids read?

When any of us read, we progressively create a mental model to place new information within a context [5,6,7]. The text itself should provide clues about how to do this, including which information should be stored and what kind of model will best incorporate the upcoming concepts. Building this model also depends on our own reading abilities and background knowledge in the relevant area [5,7]. The more work a person has to put into building the model itself, the less new information can be learned and stored [5,7]. This can be particularly limiting for young readers, whose reading skills are still developing. You want your readers to build a strong mental representation of what they have read, because then the information is more easily recalled in the future. The goal, after all, is for the young readers to learn something.

What does this mean for your Young Minds article? It means that the structure and style of your writing can go a long way in helping the young reader create a good mental representation of the scientific content in your article.

The purpose of your article should be clear from the start, and stay true to that purpose throughout [8]. Use the visual structure of writing – like section headings and paragraph breaks – to help highlight shifts in focus and key concepts [7]. Even within a given section, each paragraph should have a clear purpose. Ask yourself what the reader knew before a paragraph, what they should know after, and make sure that there is a clear path for the reader to get there. By guiding the model that kids construct as they read, you can help get them excited about a concept or discovery that they might not have been able to understand otherwise.

3 Avoiding the common pitfalls

As a researcher, you inherently have a rather extensive expertise within your own field. That expertise can make it very easy to forget what the average person knows about your field, let alone what kids may understand about it in the 3rd, 6th, or 9th grade. That expertise can also lead to the urge to explain as much as possible any time that you are able to reach out to a more novice audience. Beware that while such excitement is commendable, it can lead even the most well-intentioned science communicator down the path to a number of common pitfalls. Some of these pitfalls, and potential solutions, are highlighted below.

a. The danger of trying to explain too much at once

Typically when a researcher has only ~2000 words to explain their work, they want to use as many of those words as possible to focus on the details most specific to their own research. The language can become quite dense and leave out as many of the explanations regarding background concepts or terms that might get attention in a longer piece. For Young Minds articles it may be tempting to do the same, removing longer explanations in favor of short (and parenthetical heavy) references to what you consider well-known concepts. Remember that the goal is not to explain as much of your work as can possibly fit within ~2000 words, but rather to craft a clear and self-contained explanation that covers all that a novice reader for your target age group might need to be able to understand your work. Remember that not everything will fit into a single Young Minds article. The best starting point for this is to consider the background knowledge and existing vocabulary for your readers.

Background Knowledge – Where are your readers starting?

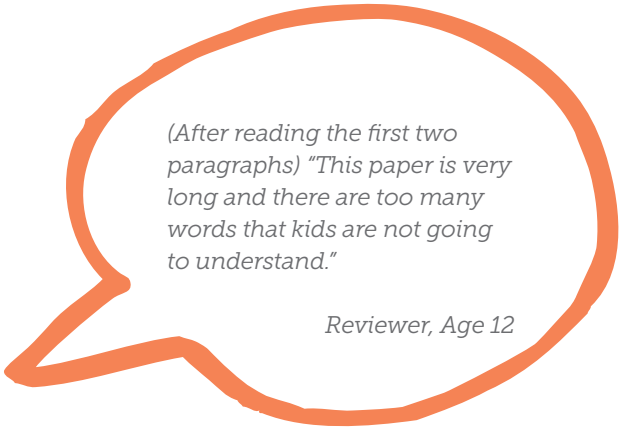
While there are basic scientific concepts that should be familiar to young readers at each grade level, the depth of that knowledge will likely vary between both kids and classrooms. When framing your article ask yourself what concepts you consider as background for being able to understand the context of your work: Plate tectonics? The existence of atoms? The concept of magnetism? Brain regions? Climate? Without this necessary conceptual framework, the new information will not have a meaningful place to go for the young reader. Depending on the grade level of your intended readers, the level of explanation the article should contain will vary. If a concept is really key, always err on the side of explaining more deeply. Also, linking new information to other concepts that readers already know can help them place this information within their mental model. Regardless of whether your manuscript will be a New Discovery or Core Concept article type, enough explanation regarding these key background concepts should be contained for the work to have its own context [5].

This may make it tempting to just write for the oldest possible target audience, but remember that our youngest readers are just as curious and deserving of interesting articles.

Vocabulary – Balancing interesting new words with interesting new information

It may seem hard to strike a balance between wanting to include new words that are important for your discipline and not including so many new words that the sentence itself becomes meaningless to a novice reader. Consider that research has shown that to understand a text, a reader should be able to understand 95% of the words used [9,10].

When only 5% of your words can be unfamiliar vocabulary, you realize that those should be the most important ones for the young readers to learn. That way, new words can be clearly defined and then repeated throughout the text for better comprehension and retention. If necessary, you can consider creating a glossary of up to five key terms with brief and clear explanations.



Thinking about this 5% rule can also apply to the units, scales, and abbreviations you would like to include in your manuscript. Even if you include an explanation of an abbreviation once, the reader may not remember it by the time they reach the end of the article. If your research uses units of measure that kids may not be familiar with, consider not only using the full-length name, but also including an explanation of what it actually means.

b. Simplifying is not the same as "dumbing it down"

When trying to put research into simple sentence structures and clear language, it can be easy to think that the science explained does not need to be as rigorous in its accuracy. But, this idea that you are "dumbing your science down" can lead to misconceptions about your work for the young readers, and even a misunderstanding of the nature of science overall. If you would not use words like "prove" or "cause" in one of your academic pieces, do not use them for the Young Minds version. These articles are not only introducing the young readers to the content of cutting-edge science, but also providing important insight into the scientific process itself.

There is also a big difference between not knowing the meaning of certain words and not being able to understand an idea, and it can be detrimental to your audience to mistake one for the other. By providing young readers with a chance to interact with complex ideas in digestible pieces, they can begin to interact with concepts like systems, uncertainty, and dependency. By providing access to these more complex concepts with clear language, we empower young people to start thinking critically about the information they have access to.

c. The misleading appeal of complex sentences

When kids start learning to read, much of their cognitive effort goes to trying to master the act of decoding the words themselves. At this point, much of their working memory is used just for the act of reading the words. If a sentence is complex in structure or too long, the meaning of the sentence as a whole can be lost because of the amount of working memory tied up on the reading of the words themselves [11].

Complex sentences (though tempting) can be a trap for trying to put too many ideas into a single sentence (like this one), which can make it harder – or at least harder than necessary – for readers to understand the content itself, which is the more important part.

With more experience, readers can move from sentences with simple structures to those with more of a memory demand. Some examples of conventional expository structures are shown below in order of increasing complexity [12]. Consider how each structure would require information or words from earlier parts of the sentence to be held in working memory to process the implication of the later parts of the sentence.

- **Description**

  "Déjà vu describes the strange experience of a situation feeling much more familiar than it should" [13]

- **Sequence**

  First, next, last

- **Compare/contrast**

  "Left- and right-handers differ in how they judge positive and negative attributes of things in the space around them" [14]

- **Cause/effect**

  It rained, so I used an umbrella

- **Problem/solution**

  I can't reach the top of the tree, so I use a ladder.

Even if older readers are able to handle longer and more complex sentences, it is important to remember there is no need for every piece of information to be presented in that complex structure. If every sentence has a new concept, or every sentence has a complex structure, there will not be much working memory left to understand and integrate the

information they are reading. Think about your own experiences with finishing a sentence without actually understanding what you had read. Integrating simple sentence structures, favoring the active voice, and limiting the amount of new information presented per sentence can enable you to help your young reader have a better chance of understanding the content you are trying to explain.

If you find yourself wanting to include sentences with nested clauses or multiple conjunctions (and, but, or, because, since, as...), ask yourself if you are trying to make the concept more clear or just trying to fit more information within a single sentence.

d. Using the right words in the right order

The previous sections highlight the important of choosing the right building blocks to make up sentences – from word choice to sentence structure – but ensuring learning goes beyond just choosing the right pieces and extends into the way they are put together. This concept of text cohesion [7] includes the flow of information through the article from start to finish. Cohesion is important within sentences, within paragraphs, and between paragraphs to create meaningful flow. That flow is part of what helps your reader build a strong mental representation of your content [5].

Some ways to make your text more cohesive include [7]:

- **Repeat important linking words** from your section header, from previous sentences, and from previous paragraphs, even if you are afraid of sounding redundant. Some redundancy is ok – it highlights important information and helps to build the mental model.
- **Put old information first and new information second.** Putting old information at the start of sentences (as I did here) tells your reader where in the mental model to place the upcoming fact. This structure can also provide links to earlier concepts and aid flow.
- **Use transition words** (first, second, next, last; because; but....) to highlight meaningful shifts or causal relationships.
- **Make explicit connections.** Do not assume your reader will see the link between the heading of a section and a conclusion you have drawn. Processing multi-paragraph arguments that lead to a single conclusion will be a new skill for many young readers. If the writing does some of this work for them, there is a better chance the reader will understand and remember it later.

e. Remember that figures serve a different purpose for young readers

In a typical academic articles, figures are used as visualizations of data. They are meant to help bolster your argument and serve as evidence for the conclusions in your work. But these scientific figures are often filled with units, concepts, or implied relationships that young readers may not even understand how to interpret. As researchers you have been trained on how to interpret the figures and visualizations most common to your field. Just putting the same figures in bright colors or with larger fonts does not mean that young readers will understand what they mean or find them compelling.

Instead of thinking of the figures in Young Minds articles as a visualization of data, think of them as a way to display meaning, visualize a difficult concept, or present connections between pieces of information that are particularly key to the article. Figures here should support or solidify concepts that are interesting or important for the young readers to understand. If they present entirely new information or are in a format that the reader does not know how to understand, they will not fit into the mental model that the reader is forming. If you find yourself writing a figure caption that is longer that ~100 words, then the image is probably trying to cover too much ground.

f. Don't assume the reader knows why something is important or exciting.

Scientists spend years of their lives investigating the concepts in their research, and in that time the importance or the excitement behind the work can take a back seat for a number of reasons. When talking about

research with other experts, it is expected that everyone focus on objective approaches as much as possible. Just like a joke might not sound funny after the 100th time you have told it, it might be hard to remember the excitement behind the work you are doing after years of staring at cells, larvae, data, etc. But for younger readers, this excitement is still fresh and it is still vital for getting them to engage in what can be hard-to-understand content. If something is exciting, convey that excitement. If something is important, say exactly why it is important rather than burying that value within a paragraph of inferences and implications.

This is particularly important to keep in mind when writing your abstract. Unlike an academic abstract, which is meant to serve as a dispassionate summary of the academic content within an article, these abstracts are meant to draw readers in. They will be prominently displayed on the article pages and will provide readers not only with a summary of what content is contained in the article but entice them to click and keep reading.

3 Practical Examples of texts and figures per age group

Examples from ReadWorks.org based on Grade and Lexile levels.

This would be appropriate for an 8 – 9 year old:

"Earthquakes are caused by the movement of huge pieces of rock under Earth's surface. The pieces are called tectonic plates. These plates are found in the top layers of Earth, called the crust and the upper mantle. Tectonic plates have rough edges and are always moving. Usually, they move slowly. But there are times when the plates get stuck against each other. If that happens, pressure builds up. When the two plates finally get "unstuck," they release energy. Often, a small amount of energy is released. That will mean a small earthquake. However, sometimes a lot of energy is released. When that happens, the earthquake that follows will be strong...and dangerous! (ReadWorks.org -- http://www.readworks.org/passages/why-are-there-earthquakes)

This would be better for a 10 – 11 year old:

"Polar Climates: Have you ever heard of the polar ice caps? The ice caps are the regions at the North and South Poles that are always covered in frozen water-- either snow or ice. Polar climates occur only above 60 degrees north latitude or

below 60 degrees south latitude. They are the coldest climates on Earth. Polar regions get less of the sun's direct rays because of the tilt of the Earth's axis. Temperatures are extremely low, especially during winter when it is dark for six months straight! Precipitation is rare and almost always in the form of snow." (ReadWorks.org -- http://www.readworks.org/passages/climates-climate-zones)

This might be best for a 12 – 13 year old:

"The High Plains aquifer was born from the action of wind, water, and a really big crash. About 65 million years ago, two tectonic plates began to collide along the western edge of North America, slowly pushing the Rocky Mountains high into the sky. Tectonic plates are enormous sections of Earth's rigid shell. Even as the mountains were being pushed skyward, wind and water began weathering (gradually breaking down) the peaks and carrying away the sediment (bits of sand and rock), says James Goeke. Goeke is a hydrologist at the University of Nebraska in Lincoln. A hydrologist is a scientist who studies water on or below Earth's surface." (ReadWorks.org -- http://www.readworks.org/passages/high-and-dry)

This might be best for a 14 – 15 year old:

"The reason why so many earthquakes and volcanoes occur here has to do with plate tectonics. On the surface of the earth is a patchwork of enormous plates, millions of square miles across and about 50 miles thick, atop which all geographic features—seas, oceans, fields, mountain ranges —sit. These plates are in constant motion, although they move very slowly—about 10 centimeters per year. When these plates shift against, or away from each other, they can cause massive events, such as earthquakes and volcano eruptions. These movements are referred to as plate tectonics. " (ReadWorks.org -- http://www.readworks.org/passages/mount-pinatubo-and-ring-fire).

Mental Checklist for as you write

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What age group is your target audience?

What have they learned about your subject area up to this point?
What science words are they familiar with in your field?
How long have they been reading and how strong are their reading skills?
What kinds of science images (pictures, charts, graphs) have they encountered before?

Building the mental model for your young readers

Manuscript

- ☐ Do your headings provide context for what the reader should expect or focus on in each section?
- ☐ Do you introduce new concepts in a way that builds from basic and familiar to more specific?
- ☐ Does your manuscript have a clear focus from the beginning and stay centered throughout?

Sections

- ☐ Does each section have a clear focus for the reader about what they should learn?
- ☐ Do you present familiar concepts first and then new concepts in connection/context to the old?

Paragraphs

- ☐ Does each paragraph have a clear focus for the reader?
- ☐ Do you present familiar concepts first and then new concepts in connection/context to the old?
- ☐ Does each paragraph make both the content and the significance clear?
- ☐ Can you read your paragraphs out loud, from start to finish, on the first try?

Sentences

- ☐ Are your sentence structures more complicated than they need to be?
- ☐ Are you using extra clauses and parentheticals to make the information easier to understand, or just to fit more information in a single sentence?
- ☐ Should important concepts and vocabulary from earlier be repeated to increase clarity?

Word Choice

Are more that ~5% of the words new for your target reader?
If you would not use words like "prove" or "cause" in one of your academic pieces, do not use them for the Young Minds version.

Are you trying to include too much in a single manuscript?

If you are making sentences more complicated and removing background information to stay within the word limit, ask yourself whether there is more to learn that should be included in a single Young Minds article.

Are you communicating your passion and excitement for the subject matter?

You think about these ideas all the time and know why they are interesting or important. Are you sharing that with your reader both directly and with your tone?

Are you making good use of your figures?

Are your figures appropriate in style for your target age group?
Are your figures meant to display meaning, visualize a difficult concept, or present important connections? (As opposed to representing data)
Are your figure captions longer than ~100 words?

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