THINK *READER*

Writing by Design:
Reader-based techniques
to improve your writing

JEAN-LUC
LEBRUN

Think Reader

Writing by Design: Reader-based Techniques to Improve Your Writing

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To my son and partner at Scientific Reach, whose copy-editing skills are simply outstanding. He also contributed examples and designed the book cover.

Contents

Preface

Before you became a writer, you were a reader. You were a regular reader, not a mythical reader with infinite attention, infinite time, infinite memory, and just the right amount of knowledge required to understand everything you read. That is why you often struggled when reading. When the writer just made it too hard to sustain your attention and meet your needs, although highly motivated at first, you rapidly lost interest.

Writing to make reading easy **is hard**. It took you weeks of effort, years maybe, to understand the topic you are writing on. To understand you, your readers have hours, minutes maybe. They are in a hurry. They have always been in a hurry. Case in point, in **1905** Professor Clifford Allbutt wrote, "At present few people have time to wade through pages and pages of discursive and ill explained writings on the off chance that they may ultimately light on an interesting result."

Writing that reads fast, reads well, and interests, is not straightforward. It requires design. Your writing is an intellectual product consumed by the mind of a reader. You are its designer and 'mindufacturer'. Ask yourself how good your skills are in product design? Do you know how much reader memory and attention writing consumes? Do you know how a reader reconstructs meanings from words? In short, do you know about reading and readers? You should if you want to design reader-centered writing.

The book includes 130 examples to illustrate the design principles of reader-centered writing. A hundred plus examples will help you understand what distinguishes good from bad design. With that knowledge and with the tools described in the tools chapter, you will be able to evaluate your own writing.

The book also includes 25 "swimming" exercises, some in shallow pools, some in deep pools. Get your feet wet. One does not learn swimming by watching others swim! Discover your writing style. Find out what does not read well. In short, be your own copy-editor.

I added six stories to make reading this book more story-like, plus a chapter with over fifty multiple choice questions to test your knowledge. Finally, I made sure that the book's readability score is low enough to be accessible to all, and in particular to non-native English writers. I am who you are. I know how difficult it is to write clearly. This book is also written for you.

There is no need to read this book linearly. I do recommend you read the first two chapters, and then, jump directly to a chapter that best fits your needs. Your writing is complex? Start with the chapter on memory. Your writing is dull? Start with the chapter on attention. Your writing is unclear? Start with the chapter on knowledge. Your writing is choppy, lacks fluidity? Start with the chapter on expectations. Your writing is unconvincing? Start with the chapter on persuasion. Your visuals are complex, ineffective? Start with the chapter on visuals. Or Enjoy them all!

Newton had his giants. He saw further afield by standing on their shoulders. My giants are Dr. George Gopen, and Dr. Don Norman. Dr Gopen is Professor Emeritus of the Practice of Rhetoric at Duke University. His book "Expectations, Teaching Writing from the Reader's Perspective," opened my eyes to a new fluid way of writing. Dr. Donald Norman is the director of the design lab at the University of California San Diego. His design principles expounded in "The Psychology of Everyday Things," helped me understand that writing is an intellectual product that needs design to reach its full potential. We, the writers, have to go beyond the design principles promoted by Apple—What You See Is What You Get (WYSIWYG), i.e., what is on the printed page looks identical to what is on the computer screen. We must make sure that what is on the printed page is understood by our readers as clearly as we understand it ourselves.

For that, we need to THINK *READER*.

Jean-Luc Lebrun

Chapter 1 - Role of Memory and Attention in Reading

As a reader, I know that my wish to remember everything and maintain attention throughout my reading, is an impossible wish. Somehow, things get sorted out, filtered, registered, missed, stored, or discarded, seemingly beyond my control. Why did I miss this important fact the first time I read this text? Did I not pay attention, and if so why? Is my attention the problem or is it the way the text was written? But what if I did pay attention but do not recall reading about that fact; Is my memory the problem, or is it the way the text was written? If only I knew how memory and attention worked in reading, their mode of action, and also their limitations, I could understand how to read better, ***and even how to write better****.*

Memory

Memory's mode of action

Reading is a fantastically complex task. When your eyes scan text, your mind decodes and stores the meaning of the words in short-term memory. When you read "a red car," you create in your mind's eye the image of a red car. You decode the written word (a high level of abstraction) and encode it into something different, the image of an anonymous car. As you read through the sentence, **your mind processes reading in chunks of information buffered in the short-term memory**.

> Condensation droplets merged to form rivulets of water that streaked down the window and pooled on the windowsill.

The image in your brain is diffused and static at first, then crystallizes and becomes dynamic when the droplets merge to form rivulets that streak down the window—the missing context. The image then changes dynamically to include the windowsill. The words create a wide cinematic tilt down zoom out effect. The writer is the cinematographer. Could you produce in writing the reverse cinematographic effect?

> On the windowsill a pool of water formed, fed by the rivulets that streaked down the window draining condensation droplets on their way.

In summary, the immediate task of the short-term memory is to help the reader store both the words and the images they create long enough for the reader to reach a point of closure in the sentence. Once a sentence is understood, the memory does not carry forward its cargo of words into the next sentence. It carries only the smallest of baggage in its briefcase.

In that memory briefcase are four things:

- the few words that end the sentence
- what this sentence is about (its topic)
- if the words created an image, that image, a sound, that sound, a smell, that smell, a feeling, that feeling
- if the sentence created expectations, these expectations

The few words that end the sentence

The last words in a sentence linger briefly in short-term memory to help the reader see the connection between two successive sentences.

> At four o'clock, in the large icy courtyard eroded by the rain, *I found myself alone with Meaulnes. Both of us*, without a word, were watching the town losing its shine as it dried under gusts of wind[a].
>
> [a] Le Grand Meaulnes, Alain Fournier, 1913. (My translation).

Myself with Meaulnes is repeated in *Both of us*. The repetition acts as a handshake to help the reader see how the two sentences connect.

What this sentence was about (its topic)

A sentence has a verb, the verb a subject—the actor of the verb's action.

> Mary stopped her car on the road shoulder, stunned by the wondrous Nordic landscape.

Grammatically speaking, the topic of a sentence is often the subject of the verb in that sentence. The sentence is about "Mary," and the rest of the sentence describes what she does. The topic (here Mary) acts, so attention keeps it in your mind's eye, as it is expected to reappear in the next sentences. You would not expect the next sentence to start with "The man was cleaning the dishes". However, if it started with "She let its soothing peace penetrate her soul," it would make sense because the new sentence stays on topic.

If the words created an image, that image, a sound, that sound, a smell, that smell, a feeling, that feeling

While being read, concrete words form an image.

> Sheep quietly grazed in the flooded meadow under the brooding sky.

Whenever I read a sentence like this one, the same silent image comes to mind, that of a scenery in French Brittany with Mont Saint Michel in the background. The image that comes to your mind is bound to be different from mine, and that's fine. Even if I showed you the scene I photographed, it would not recall (it does for me) the smell of damp air that lingered after the downpour, and the incredible feeling of peacefulness. Whatever image you recall, it encodes a richer summary of the sentence than the words sheep, graze, meadow, brooding sky, flood, and quiet. Such visual sentences are a great example of the expression 'the whole is greater than the sum of its parts.'

Read each of these sentences, pausing after each one to consider its mental image.

> Flight of the ball towards the catcher's mitt took place.

Reflect on the picture you formed. Now read this!

> The ball flew towards the catcher's mitt.

See anything? With the last sentence, I saw a ball flying towards a person ready to catch it with a gloved hand. Another person I asked even saw a stadium besides the ball, the catcher and his mitt. His mind had automatically added the context. In contrast, the first sentence uses the word "flight," an intangible concept. One can see, hear, and grab a flying ball, but one cannot see, hear, or grab flight. Similarly, one can see a falling man, but not a fall from grace, as the first is concrete and the other abstract. The more concrete words a sentence has, the easier it is for the reader to visualize the situation described.

If the sentence creates expectations, these expectations

> Right after President Trump was elected, the scientific scene drastically changed.

The sentence raises the expectation that the writer is about to expound what changed. The word *drastically* heightens curiosity. Your attention focuses on a new target: the changes. Should the writer fail to deliver on the expectations raised, or should the claim of drastic change be unsupported, you would be disoriented and frustrated. But should the writer deliver on these expectations, you would move speedily through the text, pulled forward by them.

Our reading brain is in pursuit. It constantly anticipates the near future based on the past. Therefore, fuel anticipation by writing expectation-raising sentences.

Knowing what our working-memory contains, how can we write to benefit from the memory's mode of action?

1. Write the end of a sentence with great care. It plays a pivotal role.
2. Write sentences that create images. They are easier to remember.
3. Write to delineate the main actor in the sentence.
4. Write to create expectations.

Memory's drawbacks and limitations

1- **Long-term Memory is reprogrammable**. It can be altered and over-written by short-term memories of similar events.

2- **Memory recall is not perfect**. Have you ever had the feeling that you've been somewhere before, while knowing it cannot be so? You have? You are not alone. This happens when there are enough similarities between your location and a memory of where you were. The same applies when someone's facial features stored in memory resonate powerfully with a face you are seeing for the first time, and you say, "Haven't I seen you before?" As a lecturer seeing thousands of faces over the years, I have mostly been accurate, and even astonished people with the accuracy of my recollection, but I have also been wrong… and embarrassed!

Time to get your feet wet!

Read all these words: tumbler - wash - cycles - shirt - pants - spin - rinse - setting - dryer - clothes - powder - delicate - machine - socks
Without re-reading the list, did the list contain the word wool ? Did it contain the word washer? Did it contain the word washing machine?

Because a washing machine is the mental image created from the words in the list, some will be convinced that one or several words mentioned are in the list. This shows that, while reading, the memory not only grows to contain the words read, it also adds the larger context. When you see a washing machine for the first time, the memory stores more than washing machine features. It stores its location, the noise it makes, the hot and cold water pipes connected to it, and more. As Dr. Bain, the Scottish philosopher, logician, and educationalist writes in his 1867 book 'English Composition and Rhetoric': "The way memory works is this: impressions occurring together become associated together, as sunrise with daylight; and when we are made to think of one we are reminded of the accompaniments[1]."

3- **Memory storage is partial**. Not everything that reaches our senses is stored. When asked questions about an event, some aspects of the event will be recalled clearly, some will be reconstructed from reason and memories of similar events, and others will not be recalled. Was the last package the delivery man dropped at your front door, to the right, the left, or the middle of the doorstep? Chances are, you don't know, because you don't care. Memory is strongly guided by attention, which is itself driven by motivation and goals.

4- **Recall is cued**. When you recite a poem or sing a song you learned, remembering a verse is often necessary for you to recall the next verse (a phenomenon called cued-recall[2]). Cued recall is best demonstrated in music when a pianist or a singer has to return to the beginning of a piece because they are unable to start from its middle. You probably now the alphabet song A,B,C,D... Try singing the alphabet song from the letter I. Much more difficult, isn't it? This cued recall follows the recent observations of Denise Cai, a neuroscientist from the Icahn School of Medicine at Mount Sinai. She found that events linked in time "share overlapping neurons"[3].

5- **Memory recall is probabilistic**. When the strength of the distributed

[1]English Composition and Rhetoric. A Manual, Alexander Bain. 1867, p.21, D. Appleton and Company New York

[2]https://en.wikipedia.org/wiki/Recall_(memory)

[3]https://www.scientificamerican.com/custom-media/mount-sinai/watching-memories-being-made/

interneuronal connections that make a memory weakens, recollection becomes more probabilistic (from *I'm almost certain* to *I think*). Only traumatic events or emotional ones create strong memories (accurate recall) by causing the release of large quantities of neurotransmitters and stress hormones ("Flashbulb memories[4]").

6- **Encoding and recall are affected by stress**. Cortisol, a stress hormone, enhances or blocks synaptic plasticity without which memories cannot form. For simple tasks, high levels of stress hormone actually help encoding and recall, but for complex tasks, when attention is divided, encoding (learning) and recall are both low[5]. You may have experienced needing more time to think when pressed for an answer, yet, as soon as you relaxed, the answer came!

7- **Old memories interfere with younger ones**. Habits resist change. Neurons are not bowling pins easily knocked out. All the better for us. This rigidity, however, affects the encoding of younger memories. If someone asked for a phone number you recently changed the old number might be the first to come to mind instead of the new one.

8- **The memory stores less than 30 seconds in the frontal cortex**. This explains why the reader who reads a long complex sentence (50 words and more) cannot remember its beginning by it ends, especially if it contains long words.

What can the writer do to avoid the drawbacks and limitations of a reader's memory?
1. Refresh people's memory (with small recaps, summaries) to combat long-term memory alteration.
2. Before you write down recalled facts, check your recollection. It may not be accurate.

1. If you wish to return to topics you covered in earlier sections of your text, add sufficient context to improve recall.
2. Build contrast in your text. The more you do, the greater the interest and emotions, and the better the recall.

[4]Flashbulb memories. Brown R, Kulik J. Cognition. 1977;5(1):73–99.

[5]The Temporal Dynamics Model of Emotional Memory Processing: A Synthesis on the Neurobiological Basis of Stress-Induced Amnesia, Flashbulb and Traumatic Memories, and the Yerkes-Dodson Law. Diamond, David M. et al. Neural Plasticity 2007 (2007): 60803. PMC. Web. 5 Sept. 2018.

3. Stay on topic. Exhaust everything you have to write on a topic before changing it. Going back and forth between topics divides the attention. It weakens memorization.
4. Write more about what you do than about what others do. Giving other people's work too much prominence will reduce what readers remember of your work.
5. Write a long sentence as you would build a snowman, starting from a core you roll in the snow. Write so that what a reader first reads helps understand what the reader reads next. That way, the reader does not need to remember the beginning, because it has coalesced into the rest. If the reader has to wait until the end of a long sentence for its meaning to emerge, what started it will probably be forgotten, as seen below.

> When spinning speed, washing powder quantity, water temperature, and duration of cycle are carefully adjusted, the conditions are met to maintain clothing integrity and obtain out of a washing machine the best results for delicate clothing.
> **Let's rewrite this sentence by accreting information**.
> For a washing machine to best clean without affecting delicate clothing, one should limit spinning speed, washing powder quantity, water temperature, and duration of washing cycle.

Attention

Attention's mode of action

Attention acts as a catalyst and facilitator of thoughts. It puts a do-not-disturb sign on the door, dulls the sense of time, and controls eye focus while the reading brain does its word and thought processing on memory content.

Attention focuses the reader. It does that by subtracting, occulting, or blurring from the mind's eye what is judged irrelevant or distracting. Odi, the Italian psychologist, mentioned the inhibitive role of attention[6].

For a stunning demonstration of this, visit the following link and watch this video[7].

If you are still reading, please take out your smartphone or laptop and watch the video before proceeding. You will not regret it.

All done? Spoilers ahead: When told to pay attention to the team in white, you ignored anything else in the video. When watching the video for a second time, without attention guiding your focus, it seems almost unbelievable that you missed such a crucially interesting detail: the moonwalking bear.

Same effect in text: read separately the text in Bold and the normal text.

> **The** the **old** gardener's **man** wife **pruned** prepared **the** tea **fruit** and **tree** cake **and** for **watered** her **his** husband **lawn**.

[6] l'Inibizione. dal punt. di vista fisico-pathol. Odi, Fratelli Bocca, Turin 1898.
[7] www.youtube.com/watch?v=Ahg6qcgoay4

Attention is a memory enhancer. The longer we focus, the more we enable the working memory to retrieve from long-term memory what it needs to build a clear image. It is like retrieving high resolution jpeg images from your photo library. They first appear in low resolution and gain full clarity as more layers of image details are added.

Attention comes in two varieties: spontaneous and voluntary attention.

*Spontaneous attention is a reflex. The great scientist Pavlov called it the "What is" reflex. It reacts to the new, the unexpected, and the unknown. For example, at night time, when the light does not turn on after you flick the light switch, you do not choose to focus your attention, you react with powerful interest or curiosity… or fear! As a writer, you must therefore master the art of capturing the reader's attention, using the attention reflex as a tool to keep the reader engaged in your story or argument. We will see how in later chapters.

*Voluntary attention is a preparer. It inhibits its feather-trigger spontaneous cousin. It removes the irrelevant and the unnecessary from brainsight. It empties a memory still encumbered with past things and past thoughts. It prunes the tree of possible actions. As it prepares, it helps us adapt to new situations.

Attention's drawbacks and limitations

1- **Attention exaggerates**[8]. It gives greater importance to what it focuses on, at the expense of the rest. Like a magnifying glass, it enables you to emphasize some things while de-emphasizing others, thus creating distortion. Perhaps writer-raised attention may compromise objectivity and promote writer bias. For example, imagine reading the following sentence in a brochure advertising a gym: "Weight gain can be combated through dieting, choosing healthier foods, and especially, exercising regularly". In this sentence, the writer steers the reader's attention towards exercise—which is fair, since it is written to advertise a gym. But it may also create a biased view of exercise in your mind, as it implies that regular exercise is the most important of all three weight-loss factors, while research shows

[8]Information Anxiety, Richard Saul Wurman, batam books 1990.

it is not[9].

2- **Attention is strobed**, **not constant**. The orchestration of attention between multiple tasks remains a mystery. A 2018 study [10] reveals that we do not continuously pay attention to a task, but do so at the low frequency of theta waves (4 to 7 times per second). This observation is consistent with the distribution of attention serially across different tasks, and attention's interruptible nature. Different trains of thought cross the brain while you are writing. Since it is essential to capture them before they escape, you interrupt the logical flow between sentences to insert sentences that describe these new thoughts. Attention-interrupted writing is chaotic writing. Such writing is characteristic of first drafts.

3- **Attention fades rapidly**. As you read sentence after sentence without clear understanding, or without making progress towards your goal, your brain lacks motivation and stimulation, and your vigilance decreases. When that happens, selective attention removes its "do-not-disturb" sign, loosens its hold on memory, and lets other tasks knock at its door, such as "Hum, I could do with some coffee right now" or "time to stop and wash my car before we visit the in-laws," or worse "I'll read this other paper instead, this one is difficult". Losing reader attention can result in anything from benign distractions to discontinued reading.

4- **Attention is partially and temporarily under writer control**. The writer may solicit it, but cannot forcefully demand it from the reader who may independently decide that other points deserve attention—points that the writer did not intend to emphasize. Or, the reader may disagree with the writer and disregard sections the writer considers essential. *In the tug of war for attention between writer and reader, the reader always wins.*

5- **Attention distracts**. Distraction is an unwanted byproduct of attention. Jargon distracts. An unknown word distracts. I often interrupt my reading to look up a new word in the online dictionary. This detour in reading may be helpful if it helps me better understand the sentence, but it also decreases reading speed, and I often have to reread the sentence to refresh my memory. Other frequent distractions present in a text are footnotes.

[9]Physical activity does not influence obesity risk: time to clarify the public health message. A. Luke, R. S. Cooper. International Journal of Epidemiology, 2014; 42 (6): 1831 DOI: 10.1093/ije/dyt159.

[10]A Dynamic Interplay within the Frontoparietal Network Underlies Rhythmic Spatial Attention, Ian C. Fiebelkorn, Mark A. Pinsk, Sabine Kastner, Neuron, VOLUME 99, ISSUE 4, P842-853.E8, AUGUST 22, 2018

Some readers ignore them or read them when they reach the bottom of the page. I read them immediately.

6- **Attention is disarmed by habit and emotions**. At first, attention helps memory learn, but with repetition the mind uses automatisms that no longer require attention. If we had to pay attention to everything as if everything was new, we would live in a permanent and exhausting state of excitation. Habits are ways to economize attention, but habits also disable our critical sense. Have you ever failed to notice a change in the appearance of somebody you see everyday? I have, frequently! Our own emotions, for example impatience, also divert our attention, by channeling it towards our own feelings, away from our intellect.

7- **Attention excludes**. Narrowing the scope to better concentrate on what matters has its drawbacks, as the YouTube video demonstrated earlier: told to concentrate on the ball, we missed the bear. Magicians use that characteristic to their advantage.

8- **Frustrated attention generates impatience**. When you actively look for something that is late in coming, or comes but does not satisfy you, impatience rises. When the progress bar on your computer screen seems to freeze, time, which had lost its acuity when the bar was fast moving, is now perceptible. **Attention hungers for constant rewards**.

9- **Attention may depend on intelligence and knowledge**. In his "elements of rhetorics", Richard Whately, Oxford Scholar, and Rhetorician, remarks that, while reading, people *much quicker at catching the sense of what is expressed [concisely] are incapable of long attention, and are not only wearied, but absolutely bewildered, by a diffuse, [prolix] style.*

Therefore, in your writing,
1. Use attention's power of exaggeration to create mountains in an otherwise flat landscape. But if every sentence is a mountain, your reader will lack perspective.
2. Rewrite and restore order once all your thoughts are captured.
3. Wake up dwindling attention, by resetting it often with paragraph changes, and long-short sentence patterns. Avoid passive sentences.
4. Welcome reader-control of the thoughts your writing triggers. You are having an impact. But beware of miscommunication! Write clearly.
5. Put distractions, or tangential remarks out of sight in footnotes, or remove them altogether.

6. Economize reader attention. Repeat in summaries. Avoid acronyms and unexplained jargon. Do not replace keywords with synonyms, repeat them often. Stay on topic.
7. Separate the paragraphs or sections that cater for a different audience (for example experts vs.non experts), so readers can easily skip what little interests them.
8. Write summaries for impatient readers. Write your sections using the *essential first - details later* approach. Use time-saving visuals.

Optional Readings on the Brain Chemistry Behind Memory and Attention

The brain chemistry behind memory

There you are again, standing in front of an open fridge, struggling to remember what you came to fetch. For someone able to understand complex technical documents, not remembering why you got up and walked to the fridge can surprise!

This short-term characteristic of our memory has been known since antiquity. Roman philosopher Quintilian calls short-term memory "the abnormally rapid memory [which] fails as a rule to last and takes its leave as though, its immediate task performed, it had no further duties to perform." Quintilian would never have imagined that a gene (Npas4)[11] could control how our memories are stored in clusters of neurons in the hippocampus. He would never have believed that one can now locate and even erase the specific memory of a past event[12]. He had not yet understood that memory has two filing cabinets, one for short and one for long term storage, and that what is directed to the short-term memory is also simultaneously directed to the long-term memory where it will mature over two weeks[13]. Quintilian had many brain waves in his productive life, but he knew nothing about his own neurons firing synchronously to create bursts of high-frequency gamma waves (for content) and low-frequency beta waves (for attention) that interact to provide accurate memory recall[14]. He would have been stunned to see that people control devices using these waves only.

Since memories are stored along the synapses, the brain needs synaptic plasticity[15] to allow memories to gel or grow, to enable neurons to rewire themselves in different configurations, and to allow these networks to

[11]http://news.mit.edu/2011/hippocampus-memory-genes-1222

[12]http://news.mit.edu/2012/conjuring-memories-artificially-0322

[13]http://news.mit.edu/2017/neuroscientists-identify-brain-circuit-necessary-memory-formation-0406

[14]Gamma and beta bursts during working memory readout suggest roles in its volitional control,M. Lundqvist et al., Nat Comm, 9:394, 2018.

[15]https://en.wikipedia.org/wiki/Synaptic_plasticity

strengthen or weaken over time through the time-dependent mechanism of •Jargon warning• Long-Term Potentiation[16].

It is difficult to separate long-term memory from knowledge, since most knowledge is memorized, stored in neurons, each one the size of 4 to 100 microns with hundreds to thousands of synapses. Imagine billions of these neurons, with no neuron king, no master neuron in charge of it all. Imagine them working in parallel, competing, collaborating, facilitating, blocking, consolidating, self-organizing in stable specialized networks also able to modify themselves. Researchers comparing the patterns of neuronal activities in blind and sighted people have found that *conceptual* knowledge relies on a *distributed* cortical representation independent of the more local visual or auditory representation[17]. What enters the brain through our eyes and other senses is processed efficiently to make up the brain's semantic knowledge network.

The brain chemistry behind attention

Attention is a divisible entity. It can therefore be distributed among a number of tasks with different levels of intensity. Divided attention is consistent with the observation of multiple brain neurotransmitters involved in attention: •Jargon warning• acetylcholine may regulate selective attention whilst noradrenaline seems to play a role in raising attention.[18]

The attention-sustaining role of •Jargon warning• Dopamine, another neurotransmitter, was established when researchers found that people with Attention Deficit Hyperactivity Disorder[19] do not produce enough dopamine. Dopamine has been associated with the feelings of happiness we need to renew our motivation[20]. When a reader finds or hopes to find

[16]https://en.wikipedia.org/wiki/Long-term_potentiation

[17]"How concepts are encoded in the human brain: A modality independent, category-based cortical organization of semantic knowledge." Giacomo Handjaras, Emiliano Ricciardi, Andrea Leo, Alessandro Lenci, Luca Cecchetti, Mirco Cosottini, Giovanna Marotta, Pietro Pietrini. NeuroImage, Volume 135, 2016,Pages 232-242.

[18]Brain, Volume 125, Issue 11, 1 November 2002, Pages 2581–2582, https://doi.org/10.1093/brain/awf244

[19]A Concentration Killer: Study Shows Brain Chemistry Defect Is Key To Attention Deficit Hyperactivity Disorder In Adults. Society For Neuroscience. ScienceDaily. ScienceDaily, 14 August 1998.

[20]From motivation to action: functional interface between the limbic system and the motor system. Mogenson, G. J., Jones, D. L. & Yim, C. Y. Progr. Neurobiol. 14, 69–97 (1980).

satisfaction in reading, the same neurotransmitter continues to engage the brain in sustaining and renewing reading attention and memory.

Dopamine and its companion neurotransmitter, acetylcholine, are also implicated in brain plasticity essential for memorization. Here again we see how closely related attention and memory are.

The physiology of attention

The physiology of attention became a topic of research only at the end of the nineteenth century. Physiologists and psychologists then observed that, in attentive people, several physiological changes take place: facial muscles contracted, giving the face a typical expression (sometimes accompanied by frowns), the body is kept relatively but actively immobile (movement correlates well with lack of attention), and the eye's lens flattens for greater visual precision and acuity. These characteristics help us determine people all eyes and all ears from those who aren't. Many common idioms describe the physiological traits of people in a state of alert: *to be on the edge of one's seat, to be on your toes, quick on the trigger*, etc. Attention increases the speed of our actions. The eyes of an attentive reader will rapidly shuttle between a paragraph and a table or a graph. This rapid eye movement helps ensure the information in memory is constantly refreshed.

Scientists have recently discovered that a part of our brain, •Jargon warning• the Ascending Reticular Activating System[21], filters the signals sent from our senses to let us focus on what is important. Attention is directly under its control. But so are our movements, heart pace, blood flow, and more. It should therefore come as no surprise that attention has been associated with modification of breathing[22], pulse patterns[23], and regional blood flow in the midbrain[24].

[21]https://en.wikipedia.org/wiki/Reticular_formation

[22]The Influence of Prolonged Intellectual Labor and Mental Fatigue upon the Respiration. Obici, Experimental Rivista III and iV, 1901.

[23]Influence of prolonged mental work on pulse. Vaschide, Année psychologique volume IV, 1898.

[24]Activation by Attention of the Human Reticular Formation and Thalamic Intralaminar Nuclei,Shigeo Kinomura, Jonas Laresson , Balazs Gulyas, Per E. Roland, SCIENCE 26, JAN 1996 : 512-515.

Your take-away: *Memory (short- and long-term) and attention are key to reading efficiency. They are the product of complex chemical, electrical, and biological processes. They are not easily extended, and they are not easily controlled. The reader-centered writer must manage these resources to keep them within their operating range for the reader's benefit.*

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