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Module 4

Attention

Neuropedagogy

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Erasmus + Strategic Partnership for Higher Education

ATTENTION

HOW DO YOU DIRECT YOUR STUDENTS' ATTENTION?

If attention is misdirected, learning can get stuck. (Dehaene, 2020:149).

The quote above from one of the leading neuroscientists in the world, Stanislas Dehaene, makes clear that attention is crucial for learning. Our brain is always paying attention (Koenig, 2010). However - and perhaps to the frustration of many teachers - not always to what teachers would want.

In this module, you discover what neuroscience can teach us about directing your students' attention to what you want them to learn.

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1. LEARNING OBJECTIVES

In this module, you learn:

- ❑ what attention precisely is
- ❑ the neural mechanisms involved in the process of attention
- ❑ how you can direct your student’s attention
- ❑ strategies you can use to facilitate students’ attention in your classroom

2. SELF-SCAN: QUESTIONS AND REFLECTION

Imagine one of your classes, and think about the following questions:

- How do you notice that students are not paying attention anymore?
- What do you do when you see attention dropping?
- How much time do you think your students can stay focused during the presentation of a new concept or during an activity?
- Do you structure your lessons considering the attention span capacity of the age group you teach?
- Do you notice a decline in your students' attention after a certain period?

3. WHAT DOES EDUCATIONAL NEUROSCIENCE SAY?

3.1. INTRODUCTION

Activating your prior knowledge …

- What do you already know about attention?
- How do you think attention works in the brain?

Two little experiments …

Experiment 1 (Simons & Chabris, 1999)

- Watch the video below.
- Count how many times the players in white pass the basketball.

@H5P: interactive video: video should stop at 0:39@

https://youtu.be/vJG698U2Mvo?t=4

@H5P: Free choice @

1. How many times did the players in white pass the basketball?

15

@H5P: Single choice@

2. Which animal did you see walking through the scene?

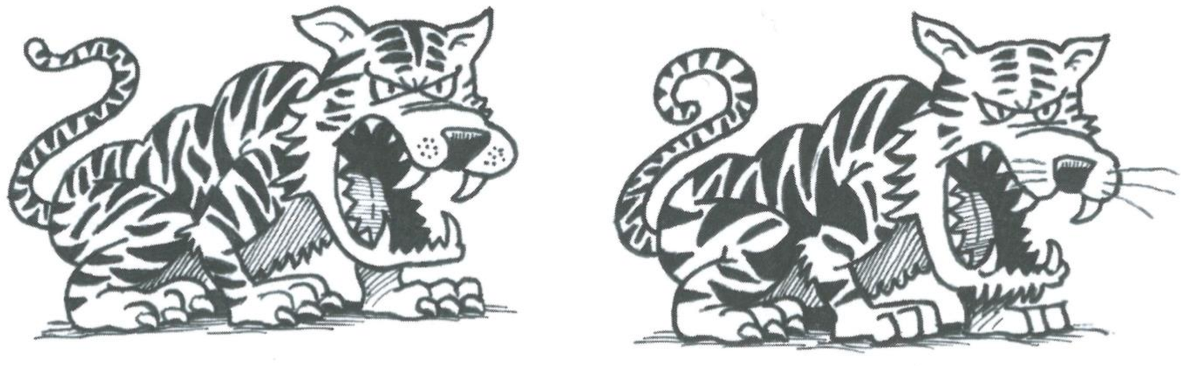
   A. Tiger

   B. Gorilla

   C. Zebra

   D. No animal

Experiment 2



Taken from Churches et al. (2017:45).

@H5P: true/false@
Were the two tigers the same?

- True
- **False**

3.2. ATTENTION… WHAT'S IN A NAME?

> *Everyone knows what attention is. It is taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrain state.*
>
> – William James (1890)

As in William James' description above, attention intuitively seems a pretty simple cognitive process. In the past three decades, neuroscience research has demonstrated that attention appears to be more complicated. If you look at the two neuroscience definitions below, the simple cognitive process doesn't sound that simple anymore and comprises different complex processes.

> *Attention refers to all the mechanisms by which the brain selects information, amplifies it, channels it, and deepens its processing.*
>
> – Dehaene (2020:147)

> *Attention is the process by which certain information is selected for further processing and other information is discarded. Attention is needed to avoid sensory overload.*
>
> – Ward (2020:203)

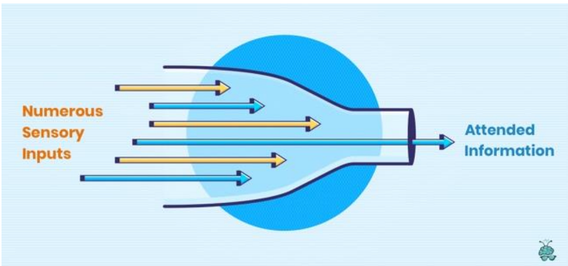
Attention, attention!

> *It is impossible for the brain not to pay attention; it is always paying attention to something.*
>
> – Koenig (2010)

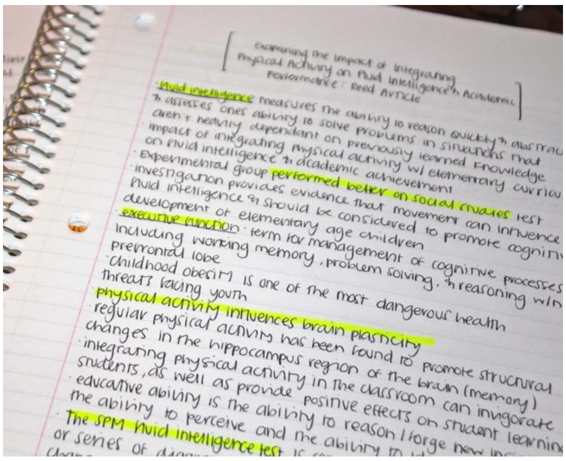
Our brain is always paying attention to something. I invite you to try not to pay attention to something. Even when we are, so to speak, “off in the clouds”, we are actually paying attention to something. There is always something we attend to. However, this also implies that we ignore other things in our immediate environment because we cannot pay attention to everything.

Attention is thus a fundamental mechanism in our brain. Without this mechanism, our brain would “crash” due to an overload of information. The cognitive process of attention ensures that certain information is given priority within the flow of information that enters our brain through our senses or that is activated by our thoughts. Or, to use two metaphors:

(1) attention is like a bottleneck because it limits the information flow to our brain;



(2) attention is like a text highlighter that makes important information in a text stand out.



What determines the priority?

This can be anything. Very often, however, the priority is determined by our ongoing behaviour or a goal we are trying to achieve. For example, if you are thirsty and want a drink, your attention will first turn to the glass on the table so that you can grab it and fill it at the tap. Once you hold the glass, your attention shifts to the tap so that you can actually fill it, and so on. In this case, we speak of **goal-driven** control: your attention is directed by current behaviour or a goal. On the other hand, a random stimulus can catch your attention as well. This is called **stimulus-driven** control. This is the case, for example, when you suddenly hear a loud bang behind you and your attention is automatically drawn to it.

Conscious and unconscious attention

Attention is very often an **unconscious** process. Most of the time, we do not have to think about what to pay attention to. It just happens. In education, however, our students often have to direct their attention **consciously**, for instance, during class or when studying for an upcoming test or exam. Sustaining attention is energy-consuming and requires effort (sometimes, a lot).

Attention and learning

> *Of all the factors that influence learning, attention to the learned material may be the most important.*
>
> \- Posner & Rothbart (2014:14)

> *The role of attention in memory encoding appears quite strong. For information to be properly encoded into memory, it is best for it be the target of attention.*
>
> \- Lindsay (2020)

Without attention, learning is impossible because noticing, selecting and prioritizing task-relevant information are fundamental to the learning process. Only if our attention is focused on the right pieces of information, this information might be integrated and stored in neural networks in long-term memory to be remembered and retrieved later. Or, to put it differently: *if attention is misdirected, learning can get stuck*. (Dehaene, 2020:149).

Since attention determines what is learned, mobilizing our students' attention is a priority. If we want our students to learn something, we must make sure that we draw their attention to the important things we want them to learn. So, as a teacher, it is crucial to think about how you can trigger, direct and maintain your students' attention on what you want them to learn.

Checking for understanding

@H5P: True/False@

1. When we are “off in the clouds”, our brain stops paying attention.

A. True

B. False

@H5P: Drag the words@

2. Attention ensures that <<**certain information**>> is given <<**priority**>> within the flow of information that enters our brain <<**through our senses**>> or that is activated <<**by our thoughts**>>. This also implies that we <<**ignore**>> other things in our immediate environment because we cannot pay attention to <<**everything**>>.

@H5P: Multiple choice@

3. *Sudden and loud laughter behind you in the classroom catches your attention.* This is an example of …

- Goal-driven attention
- **Stimulus-driven attention**
- Conscious attention
- **Unconscious attention**

@H5P: Single choice@

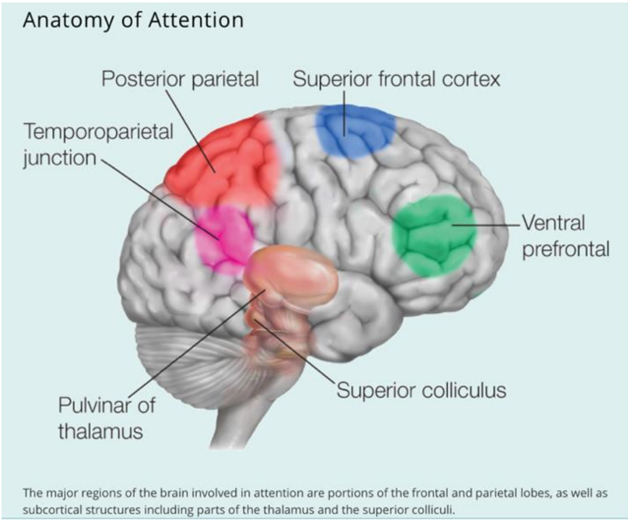
4. *If attention is misdirected, learning can get stuck*.

- **If you want your students to learn something, you must ensure that you draw their attention to the important things you want them to learn.**
- If you want your students to learn something, you must prevent they mind wander in your class.
- If you want your students to learn something, you must prevent them from focusing too long on mistakes.
- If you want your students to learn something, you should remove all distractions in your classroom.

3.3. HOW DOES ATTENTION WORK IN THE BRAIN?

> *(…) it is now possible to view attention much more concretely as an organ system, with its own functional anatomy and its own evolution and development. This system can be further broken down into at least three constituent networks.*
>
> – Posner (2012:1-2)

There is no single location in the brain that is responsible for attention. More popular literature often refers to the *formatio reticularis* in the brainstem, but this is a neuromyth (Churches 2017:47; Kolb & Whishaw 2021:66). Attention involves several cortical and subcortical areas in our brain, as shown in Figure 1. These areas form networks, each responsible for a different aspect of attention.



The major regions of the brain involved in attention are portions of the frontal and parietal lobes, as well as subcortical structures including parts of the thalamus and the superior colliculi.

Figure 1: Gazzaniga et al., Neuroscience. The Biology of the Mind, 5e © 2019 W.W. Norton & Company

> *In 1949, Guiseppe Moruzzi and Horace Mongoun stimulated this area electrically in anesthetized cats. The stimulation produced a waking pattern of electrical activity in the cats' cortices. The investigators concluded that the function of the reticular formation is to control sleeping and waking and to maintain "general arousal" or "consciousness". As a result, the reticular formation came to be known as the reticular activating system. Damage to this area can result in permanent unconsciousness.*
>
> – Kolb & Whishaw (2021:66)

Three attentional networks

Michael Posner (1998, 2012), one of the world's leading neuroscientists on the subject of attention, distinguishes **three attention networks**. Each of these networks is responsible for different attention processes:

- **Alerting network (when):** this network is responsible for achieving and maintaining high sensitivity to incoming information
- **Orienting network (what):** this network is responsible for selecting task-relevant information
- **Executive attention network (how):** this network regulates the appropriate processing for a given task and monitors its execution.

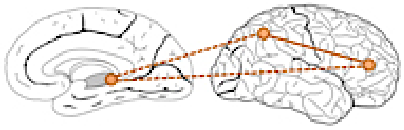
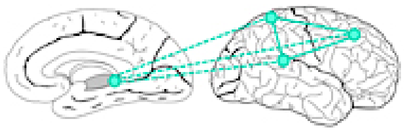
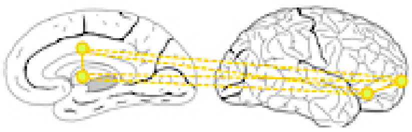
Function	*Co-activated brain structures*	*Modulator*
Alert	locus coeruleus (brainstem) frontal and parietal cortex 	Norepinephrine
Orient	superior parietal cortex temporoparietal junction superior colliculi (brainstem) 	Acetylcholine
Executive attention	ACC insula (anterior part) basal ganglia (prefrontal) 	Dopamine

Table taken from Posner (2012:19). Figures taken from Malinowski (2013).

> *Alerting, orienting, and executive control are widely thought to be relatively independent aspects of attention that are linked to separable brain regions. However, neuroimaging studies have yet to examine evidence for the anatomical separability of these three aspects of attention in the same subjects performing the same task.*
>
> – Fan et al. (2005:471)

Although each attentional network has its specific function and involves different brain structures and neurotransmitters, these three networks interact with each other in order to support learning (Callejas, Lupiánez & Tudela, 2004). Learning can be impaired if any of them is out of sync (Fan et al., 2009; Fan et al., 2005; Raz & Buhle, 2006). Lack of sleep (Mitru et al., 2002), difficulties in determining what is essential information and what is not, or inability to "resist" distractions (Levine, 2002) can cause problems with attention and learning.

> *Immordino-Yang (2011) found that an individual's attention span for a given stimulus is directly related to the type and level of affect experienced. This means that when we're interested in or enjoy a particular situation, we'll be motivated to continue the activity and will learn faster and with less resistance than we would if we'd been faced with an unpleasant activity that caused us to feel ill at ease, bored, scared, frustrated, or threatened.*
>
> – Tokuhama-Espinosa (2014:125)

Nature or nurture?

Donald Hebb (1949) initially thought that most networks for complex functions, such as attention, developed primarily through experience. Recent research, however, seems to show that these attentional networks have a common architecture amongst individuals and thus must be coded in our DNA (Fan et al., 2001; Posner, 2011:25). Individual differences in the efficiency of attention networks can be explained by genetic variation. Not everyone is equally good at focusing attention, and not everyone can focus their attention on information for the same amount of time. Michael Posner has developed an Attention Network Test to examine the differences in the three attention networks in adults and children (Fan et al., 2002; Posner & Rothbart, 2005).

Checking for understanding

@H5P: True/False@

1. The *formatio reticularis* located in the brainstem is the centre of the attentional networks in our brain.

A. True
B. False

@H5P: True/False@

2. Attention involves several cortical and subcortical areas in our brain.

A. True
B. False

@H5P: matrix sorting choice@

3. Match the attentional network with the appropriate function:

- alerting network -> when
- orienting network -> what
- Executive function network -> how

@H5P: Multiple choice@

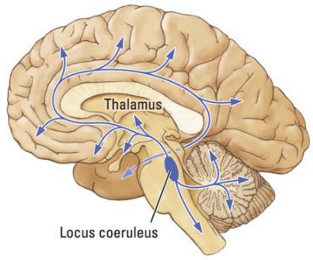
4. Your students' attention span for a given stimulus is …

A. directly related to the type and level of affect experienced.
B. the same amongst all students.
C. determined by genetic variation.
D. Indeterminable.

3.3.1. ALERTING NETWORK

> *Alerting describes the function of tonically maintaining the alert state and phasically responding to a warning signal.*
>
> \- Fan et al. (2009:209)

The alerting network signals **when** to pay conscious attention (Posner, 2012:28-47). When visual or verbal cues are perceived that something interesting, relevant, or important may happen, this system brings our brain and body into a state of alertness and vigilance. The neural basis for the alerting system seems to lie in a cluster of neurons in the brainstem, the *locus coeruleus* (Schiff & Finns 2007). This neuron cluster is responsible for producing and releasing the neurotransmitter *norepinephrine* (NE). As shown in Figure 2 by the blue arrows, their axons project to the entire cortex and various subcortical areas. The neurotransmitter norepinephrine stimulates the site targeted to detect stimuli more quickly and makes it more malleable to change its structure (Posner 2012:28ff; Kolb & Whishaw, 2021:564). For example, the reaction time to a stimulus is faster when a warning signal is presented a few seconds earlier. Using warning cues can thus stimulate students' alertness to information (Posner, 2012:19).



Figuur 2: Kolb et al., An Introduction to Brain and Behavior, 6e, © 2019 Worth Publishers

> *A teacher's job is to help the student choose the right focus by explicitly calling attention to what he considers important ("Now pay attention to this formula, because it's going to be important in solving the upcoming problems").*
>
> \- Tokuhama-Espinosa (2014:32)

Checking for understanding

@H5P: Drag the words@

1. When **<<visual or verbal cues>>** are perceived that something <<**interesting, relevant, or important**>> may happen, the alerting network brings your <<**brain and body**>> into a state of <<**alertness**>> and vigilance.

@H5P: Drag the words@

2. The neurotransmitter <<**norepinephrine**>> stimulates the site targeted to <<**detect**>> stimuli more quickly and makes it more <<**malleable**>> to change its structure. Using <<**warning cues**>> can thus stimulate students'<< **alertness**>> to information (Posner, 2012:19).

3.3.2. ORIENTING NETWORK

> *The orienting function involves aspects of attention that support the selection of specific information from numerous sensory inputs.*
>
> - Fan et al. (2009:209)

The orientation network determines **what** we pay attention to (Posner, 2012:48-71). Specifically, this system is responsible for selecting and amplifying the information relevant to (learning) goals we want to achieve. At the same time, directing attention also implies ignoring other things or thoughts considered irrelevant. This ignoring can, however, lead to what cognitive psychology calls “attentional blink” or “inattentional blindness” (Rock et al., 1992): our eyes are open, but our brain is blinking and thus missing potentially important and relevant information. A good example is the gorilla experiment at the beginning of this module. Participants are asked to count the number of ball passes a team makes in a basketball game. By focusing all their attention on counting the passes, they very often miss the gorilla running through the screen and doing a dance in the middle. As a teacher, it is therefore important to remember that when students are engaged in a task, non-relevant stimuli - in their opinion - can literally become invisible.

The orienting system can be triggered by providing cues that indicate where in space a student should direct his or her attention. As a teacher, it is crucial to be attentive that your students are in fact paying attention to what you want them to pay attention because only that information will enter and be represented in their brains. Last but not least, attention is closely related to engagement (see module 3). Attention will drop if a learning opportunity is not engaging (anymore).

At the neural level, the orienting system causes the neurons associated with the important and relevant information to become more activated and fire synchronously with neurons from the orienting system (Posner 2012:70, Dehaene 2020:154). The activity of other neurons that do not provide relevant information is reduced or inhibited.

Brain regions that play an important role in the orienting system are the superior parietal cortex and the temporal-parietal junction (see Figure 1). The superior parietal cortex becomes active during the actual directing of attention on something in the physical or mental space. There is often co-activation with an area of the frontal cortex responsible for controlling eye movements (Frontal Eye Fields). This is because we often direct our eyes towards the things we direct our attention to. The temporal-parietal junction plays a role in "disengaging" our attention so that it can be shifted to new or other relevant information. The neurotransmitter that seems to play an important role in the orienting system is *Acetylcholine* (ACh). The cluster of neurons responsible for the production and release of Acetylcholine is also located in the brainstem (see Figure 3).

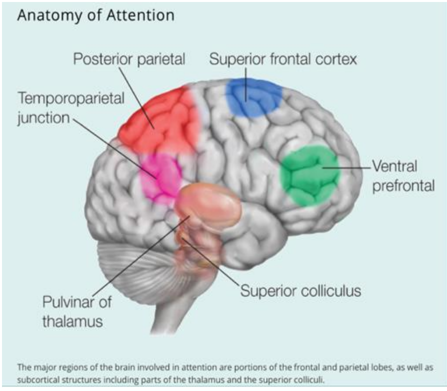


Figure 3: Gazzaniga et al., Neuroscience. The Biology of the Mind, 5th edition

Checking for understanding

@H5P: True/False@

1. Directing attention is essential for your students' learning, but at the same time, they also run the risk of missing irrelevant information.

A. True
B. False

@H5P: Single choice@

2. As a teacher, it is essential to …

- provide cues that indicate where your students should pay their attention.
- Check that your students are paying attention to what you want them to.
- Engage your student in the learning opportunity. Otherwise, attention will drop.
- **All the above.**

3.3.3. EXECUTIVE ATTENTION NETWORK

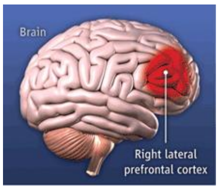
The executive attention network determines **how** the selected task-relevant information is processed (Posner, 2012:72-97). Sometimes, it is also called “concentration” or “self-regulation”. In cognitive neuroscience, this system is called the *cognitive control system* (Gazzaniga, 2019:516ff). This system heavily relies on regions in the prefrontal cortex and their connectivity to the rest of the brain. From a developmental perspective, the prefrontal cortex is the last part of the brain to mature (Casey et al., 2005). On average, the prefrontal cortex reaches full maturity between the ages of 22-25.

The executive attention network provides top-down control over behaviour and thoughts. It can be compared to a railroad yardman, who orients the switches in the proper position, so each train arrives at the right track (Dehaene; 2020:159). Or in other words, the executive attention network decides how the attended information is processed based on the current goal we want to achieve. Some tasks of the executive attention network:

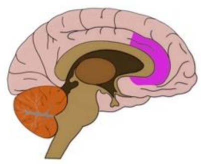
- making a plan of action
- selecting task-relevant information
- inhibiting distractions
- initiating action
- monitoring behaviour and keeping it on track
- switching strategies (if the ones chosen do not work out)

Two regions are of importance in the prefrontal cortex:

- **Lateral Prefrontal Cortex** (LPFC): working memory, a temporary buffer which represents task-relevant information stored in other brain regions (Gazzaniga, 2019:520)



- **Anterior Cingulate Cortex** (ACC): detects what is called ‘response conflict’ (Cohen et al., 2000). If ACC detects a difficult situation, it boosts the task-relevant representations in working memory.



However, there is an important caveat: working memory cannot hold two different tasks active simultaneously (*Cognitive Load Theory*; Sweller, 1988). So multitasking is impossible. In so-called “multitasking”, the brain quickly switches between task A and task B. But this switching comes at a cost: it costs more energy (task-switching costs), and more mistakes are made. If you want to take this to the test: task A: say the alphabet; task B count to 26; now switch between task A and task B: A 1, B 2, C 3, D 4, …

The executive attention network is responsible for one of the essential skills that students can and must develop. As a teacher, you can support this development by providing learning opportunities in which they learn to self-control, concentrate, monitor their learning progress, and, if necessary, adjust their ongoing learning process.

> *We cannot expect a child or and adult to learn two things at once. Teaching requires paying attention to the limits of attention, and therefore, carefully prioritizing specific tasks. Any distraction slows down or wastes our efforts: if we try to do several things at once, our central executive quickly loses track.*
>
> \- Dehaene (2020:162)

> *Thus, the available primary data do not support the concept of a 10- to 15-min attention limit. Interestingly, the most consistent finding from a literature review is that* ***the greatest variability in student attention arises from differences between teachers*** *and not from the teaching format itself.*
>
> \- Bradbury (2016:149)

If you want to read more:

- De Haan, M. (2013). Attention and executive control. In: Mareschal, D., Butterworth, B., & Tolmie, A., *Educational neuroscience*, 325-348.
- Dehaene, S. (2020). *How we learn: The new science of education and the brain*. Penguin UK, 147-175
- Posner, M. I. (2012). *Attention in a social world*. Oxford University Press.
- Ward, J. (2020). *The student's guide to cognitive neuroscience* (Fourth edition), 203-231.

Checking for understanding

@H5P: Single choice@

1. The executive attention network is also called …

- Concentration
- self-regulation
- cognitive control system
- **all the above**

@H5P: Drop the words@

2. The executive attention network provides <<**top-down control**>> over <<**behaviour and thoughts**>>. Or in other words, this network decides <<**how**>> the attended information is <<**processed**>> based on the <<**current goal**>> we want to achieve.

4. CLASSROOM ACTIONS

> *Can you learn without paying attention? No, because attention is what permits topic salience and determines the relative worth of information; without that hierarchy, there is no orderly connection of ideas, and therefore no new learning..*
>
> – Tokuhama-Espinosa (2014:121)

This section presents **inspiration for classroom actions** you can try in your classroom. As mentioned above, there is no one size fits all, so experimentation and further catering to your specific context are essential.

4.1. HOW DO YOU TRIGGER ATTENTION IN THE CLASSROOM? (ALERTING NETWORK)

> *Because learners often lack the instinct to intuit the desired focus of the class' attention, teachers must explicitly call attention to the important parts of the class. Telling students to "pay attention; this is really important" is not cheating; it is being clear.*
>
> – Tokuhama-Espinosa (2014:124)

4.1.1 At the start of your lesson

Classroom Action 1

New or unexpected things attract our attention. Think of something unexpected or unusual to start your lesson with. You can, for instance, use an interesting picture or video related to the subject matter of your class. Or you can give students an intriguing question, problem or unusual perspective that might trigger their attention. At the same time, you also trigger students' engagement (see module 3) because you create an information gap they will want to fill.

Classroom Action 2

Students pay more attention to things when they are **meaningful and relevant** to them. Think of how the subject matter relates to students' real-life experiences and/or current affairs. Make the relevance explicit at the beginning of your class and repeat it at important moments during your class.

4.1.2 Throughout your lesson

Classroom Action 3

Use **warning cues** to announce explicitly that important information is about to follow:

- You can **verbally** call attention to important moments, e.g. *"This is something very important", "Now pay attention to …"*

- You can use **visual** warning cues**.** For example, you can give the slides of your PowerPoint with essential information a different background colour. When students see this colour, it triggers their alertness and attention.

Classroom Action 4

Try to keep **distractions** such as noise, chit-chat, smartphones, confusion, other students who happen to be passing by your classroom, etc., down to a minimum. Make a list of things you have noticed to distract your students and think of possible interventions to grab your students' attention.

Classroom Action 5

Make sure students feel **safe and respected** in your class. Embrace mistakes as opportunities to learn. When students feel unsafe, their attention might be distracted by possible "threats" in their immediate environment. These distractions trigger an avoidance response and impair learning (see module 3 on engagement).

4.2. HOW TO DIRECT ATTENTION IN THE CLASSROOM? (ORIENTING NETWORK)

> *A teacher's job is to help the student choose the right focus by explicitly calling attention to what he considers important.*
>
> – Tokuhama-Espinosa (2014:32)

Classroom Action 6

> *If a student is not sure of the learning objective, she may pay attention to irrelevant aspects of the activity and therefore fail to learn.*
>
> – Tokuhama-Espinosa (2014:123)

State the **learning objectives** explicitly and show what success will look like (Hattie, 2012). These learning objectives help orient students' attention to what you want them to learn. When relevant, repeat the learning objectives throughout your class. In this way, students can redirect their attention. Last but not least, try to assess the learning objectives during your class and give students feedback so they know what steps to focus on next.

Classroom Action 7

Highlight important and key elements to draw attention to this important information:

- Provide **a visual cue** (e.g. an arrow or a frame or ...) that directs the attention to the information you want your students to focus on.
- When working with pictures or diagrams, also **physically indicate** where students should look when you explain something.

Classroom Action 8

Think of possible **external distractions** and try to keep them to a minimum.

- The **learning material** should look carefully prepared and structured. Students should focus on the content, not the flashy layout or irrelevant images. So do not overdo it and try to keep your material somewhat "sober".
- Keep your **PowerPoint** simple. Just visualize keywords, and avoid (extensive) texts as much as possible. Use pictures instead to tell your story.

Classroom Action 9

Avoid “**double assignments**” in your exercises or assignments. Make sure you practice (in the first instance) what you want to practice on. When students master the knowledge or skill, you can interleave with “distracters”.

4.3. HOW DO YOU REGULATE ATTENTION? (EXECUTIVE ATTENTION NETWORK)

The previous classroom actions are meant to support your students' attention and learning. Of course, we would like our students to do these things alone without our help. Knowing when to pay attention and which task-relevant information to select are essential skills for lifelong learning. Nevertheless, students often struggle with regulating their attention and, consequently, their learning.

If we want them to succeed in lifelong learning, we must offer our students opportunities, support, and feedback to develop and optimize their executive attention network. It might also be beneficial to model and make explicit how you, as an expert, approach a learning opportunity or how you solve a problem (Vermunt & Verloop, 1999).

> *It is clear that EFs* [= executive functions] *can indeed be improved and that is true at all ages from infants (e.g., Kovács and Mehler, 2009) through elders (e.g., Williams and Lord, 1997). However we do not know how much EFs can be improved. Does training simply nudge EFs slightly higher? Are benefits closely tied to specific types of tasks or contexts or do they generalize further than that? How long do benefits last? Are improvements just superficial and ephemeral, yielding no enduring benefits?*
>
> – Diamond et al. (2013:42)

Classroom action 10

Design **authentic learning opportunities and activities** in which students really need to:

- make a plan of action
- select task-relevant information
- inhibit distractions
- initiate action
- monitor behaviour and keep it on track
- switch strategies (if the ones chosen do not work out)

As Vermunt & Verloop (1999:274) note: *adequate diagnoses of students' learning and thinking strategies are a necessary condition to avoid these frictions* [i.e. destructive friction] *and to be able to tailor teaching to those strategies students do not master or master insufficiently.*

When designing learning opportunities, also think of

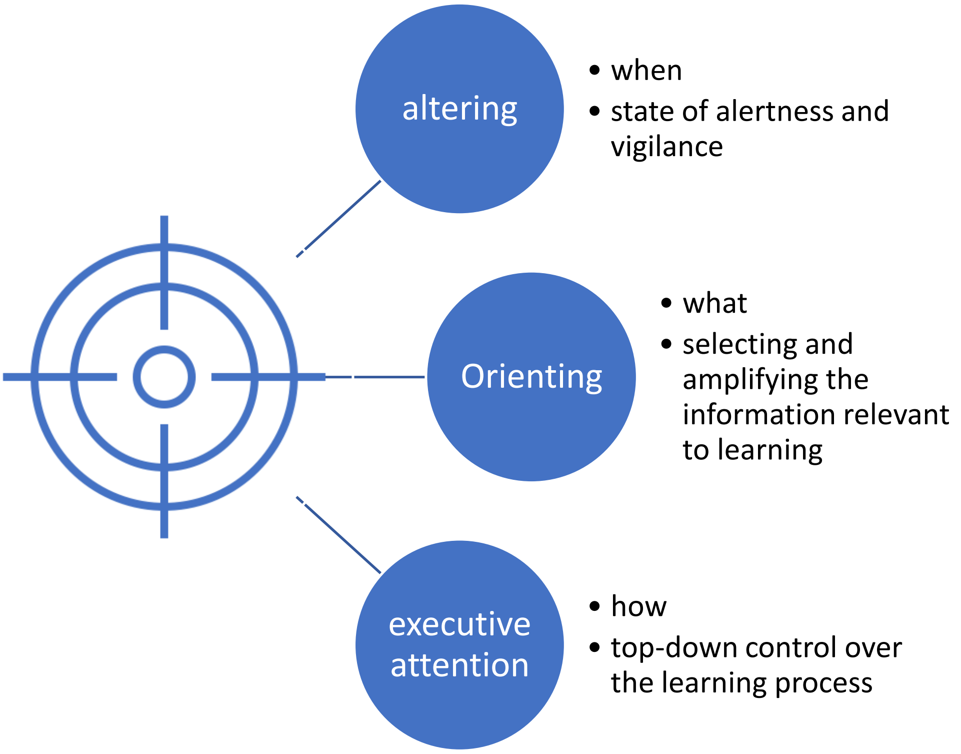
- how you are going to **scaffold** your students' learning
- how you might provide students with **prompts to reflect** their ongoing learning process
- how and when you are going to give your students **feedback**.

If you want to read more:

- Bunnik-Tibbe, P. (2021). *The effect of strategy instruction on the perceived use of learning strategies and self-efficacy with higher education students,* Master's thesis, University of Twente.
- Hartwig, M. K., & Dunlosky, J. (2012). Study strategies of college students: Are self-testing and scheduling related to achievement?. *Psychonomic bulletin & review, 19(1),* 126-134.
- Morehead, K., Rhodes, M. G., & DeLozier, S. (2016). Instructor and student knowledge of study strategies. *Memory, 24(2)*, 257-271.
- Surma, T., Vanhoyweghen, K., Sluijsmans, D., Camp, G., Muijs, D., & Kirschner, P. A. (2022). *Lessons for Learning: 12 Building Blocks for Effective Teaching.* John Catt Educational.

5. WRAPPING UP

Attention determines learning, so mobilizing your students' attention is crucial.



6. CHECKLIST

Alerting

- ❑ Start with a good **headline**.
- ❑ Relate content and activities **to real-life**.
- ❑ Make your content **salient and meaningful**.
- ❑ Use **waring cues**.
- ❑ Think of possible **distractions.**

Orienting

- ❑ State **learning objective** explicitely.
- ❑ **Highlight** key concepts.
- ❑ Create **attractive materials** that do not distract students
- ❑ Think of **inattentional blindness**.
- ❑ Avoid **double tasks.**

Executive attention

- ❑ **Provide opportunties** to develop executive attention.

7. BIBLIOGRAPHY

Bradbury, N. A. (2016). Attention span during lectures: 8 seconds, 10 minutes, or more?. *Advances in physiology education*, *40*(4), 509-513.

Brod, G., Bunge, S. A., & Shing, Y. L. (2017). Does one year of schooling improve children's cognitive control and alter associated brain activation?. *Psychological science*, *28*(7), 967-978.

Callejas, A., Lupiánez, J., & Tudela, P. (2004). The three attentional networks: On their independence and interactions. *Brain and cognition*, *54*(3), 225-227.

Casey, B. J., Tottenham, N., Liston, C., & Durston, S. (2005). Imaging the developing brain: what have we learned about cognitive development?. *Trends in cognitive sciences*, *9*(3), 104-110.

Chandler, P., & Sweller, J. (1992). The split-attention effect as a factor in the design of instruction. *British Journal of Educational Psychology*, *62*(2), 233-246.

Chun, M. M., & Turk-Browne, N. B. (2007). Interactions between attention and memory. *Current opinion in neurobiology*, *17*(2), 177-184

Churches, R., Dommett, E., & Devonshire, I. (2017). *Neuroscience for teachers: Applying research evidence from brain science*. Crown House Publishing Ltd.

Cohen, J. D., Botvinick, M., & Carter, C. S. (2000). Anterior cingulate and prefrontal cortex: who's in control?. *Nature neuroscience*, *3*(5), 421-423.

Colombo, J. (2002). Infant attention grows up: The emergence of a developmental cognitive neuroscience perspective. *Current Directions in Psychological Science*, *11*(6), 196-200.

De Haan, M. (2013). Attention and executive control. In Mareschal, D., Butterworth, B., & Tolmie, A., *Educational neuroscience*, 325-348.

Dehaene, S. (2020). *How we learn: The new science of education and the brain*. Penguin UK.

Diamond, A. (2012). Activities and programs that improve children's executive functions. *Current directions in psychological science*, *21*(5), 335-341.

Diamond, A., & Ling, D. S. (2016). Conclusions about interventions, programs, and approaches for improving executive functions that appear justified and those that, despite much hype, do not. *Developmental cognitive neuroscience*, *18*, 34-48.

Fan, J., Gu, X., Guise, K. G., Liu, X., Fossella, J., Wang, H., & Posner, M. I. (2009). Testing the behavioral interaction and integration of attentional networks. *Brain and cognition*, *70*(2), 209-220.

Fan, J., McCandliss, B. D., Fossella, J., Flombaum, J. I., & Posner, M. I. (2005). The activation of attentional networks. *Neuroimage*, *26*(2), 471-479.

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of cognitive neuroscience*, *14*(3), 340-347.

Fan, J., Wu, Y., Fossella, J. A., & Posner, M. I. (2001). Assessing the heritability of attentional networks. *BMC neuroscience*, *2*(1), 1-7.

Fougnie, D. (2008). The relationship between attention and working memory. *New research on short-term memory*, 1-45.

Gazzaniga, Michael S, Ivry, Richard B, & Mangun, George R. (2019). *Cognitive neuroscience: the biology of the mind* (Fifth edition.). W.W. Norton & Company.

Glass, A. L., & Kang, M. (2019). Dividing attention in the classroom reduces exam performance. *Educational Psychology*, *39*(3), 395-408.

Grossberg, S. (2010). The link between brain learning, attention, and consciousness. In *Causality, Meaningful Complexity and Embodied Cognition* (pp. 3-45). Springer, Dordrecht.

Hebb, D. (1949). *The Organization of Behavior*. Wiley: New York.

Kandel, E. R. (2007). *In search of memory: The emergence of a new science of mind*. WW Norton & Company.

Kane M and Engle R (2002) The role of prefrontal cortex in working-memory capacity, executive attention, and general fluid intelligence: An individual-differences perspective. *Psychonomic Bulletin & Review* 9(4): 637–671.

Ko, L. W., Komarov, O., Hairston, W. D., Jung, T. P., & Lin, C. T. (2017). Sustained attention in real classroom settings: An EEG study. *Frontiers in human neuroscience*, *11*, 388.

Kolb, Bryan, & Whishaw, Ian Q. (2021). *Fundamentals of human neuropsychology* (Eight edition). Worth Publishers.

Kolb, Bryan, Whishaw, Ian Q, & Teskey, G. Campbell. (2019). *An Introduction to Brain and Behavior*(Sixth edition). Worth Publishers.

Kyndt, E., Cascallar, E., & Dochy, F. (2012). Individual differences in working memory capacity and attention, and their relationship with students' approaches to learning. *Higher Education*, *64*(3), 285-297.

Levine, M. (2012). *A mind at a time: How every child can succeed*. Simon and Schuster.

Malinowski, P. (2013). Neural mechanisms of attentional control in mindfulness meditation. *Frontiers in neuroscience*, *7*, 8, https://doi.org/10.3389/fnins.2013.00008

Mitru, G., Millrood, D. L., & Mateika, J. H. (2002). The impact of sleep on learning and behavior in adolescents. *Teachers College Record*, *104*(4), 704-726.

Moreno, R., & Mayer, R. E. (1999). Cognitive principles of multimedia learning: The role of modality and contiguity. *Journal of educational psychology*, *91*(2), 358.

Pashler, H., Johnston, J. C., & Ruthruff, E. (2001). Attention and performance. *Annual review of psychology*, *52*(1), 629-651.

Petersen, S. E., & Posner, M. I. (2012). The attention system of the human brain: 20 years after. *Annual review of neuroscience*, *35*, 73.

Posner, M. I. (2004). *Cognitive neuroscience of attention*. Guilford.

Posner, M. I. (2012). *Attention in a social world*. Oxford University Press.

Posner, M. I., & Rothbart, M. K. (2005). Influencing brain networks: implications for education. *Trends in cognitive sciences*, *9*(3), 99-103.

Posner, M. I., & Rothbart, M. K. (2014). Attention to learning of school subjects. *Trends in Neuroscience and Education*, *3*(1), 14-17.

Raz, A., & Buhle, J. (2006). Typologies of attentional networks. *Nature reviews neuroscience*, *7*(5), 367-379.

Schwabe, L., & Wolf, O. T. (2010). Learning under stress impairs memory formation. *Neurobiology of learning and memory*, *93*(2), 183-188.

Simons, D. J., & Chabris, C. F. (1999). Gorillas in our midst: Sustained inattentional blindness for dynamic events. *perception*, *28*(9), 1059-1074.

Tokuhama-Espinosa, T. (2014). *Making classrooms better: 50 practical applications of mind, brain, and education science*. WW Norton & Company.

Vermunt, J. D., & Verloop, N. (1999). Congruence and friction between learning and teaching. *Learning and instruction*, *9*(3), 257-280.

Ward, J. (2020). *The student's guide to cognitive neuroscience* (Fourth edition). Routledge.

Weinstein, Y., Madan, C. R., & Sumeracki, M. A. (2018). Teaching the science of learning. *Cognitive research: principles and implications*, *3*(1), 1-17.

Weinstein, Y., Sumeracki, M., & Caviglioli, O. (2018). *Understanding how we learn: A visual guide*. Routledge.

Wolf, O. (2017). Chapter 31 - Stress Effects on Learning and Memory in Humans. In *Stress: Neuroendocrinology and Neurobiology,* 309-315.