Cortica
www.revue-cortica.net | ISSN : 2813-1940

Perspective
Cortica 2023. *2*(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

THE ROLE OF THE SALIENCE NETWORK AND THE DEFAULT MODE NETWORK IN SECOND LANGUAGE LEARNING

*Ivana Juric

CAS en Neurosciences de l'éducation, Université de Fribourg, Suisse

***Auteure correspondante** : Mme Ivana Juric ivanajuric973@hotmail.com

Citation : Juric I. (2022). The role of the salience network and the default mode network in second language learning. Cortica *2*(1) 10-29 https://doi.org/10.26034/cortica.2022.3344

1. INTRODUCTION

Second (L2) and third language (L3) learning is an important part of the school curriculum in multilingual Switzerland. Children start learning L2 already at primary school and continue all through middle and high school.

I have been teaching L2 and L3 at vocational schools in Fribourg for seven years now, and year after year I observe the same situation in my classes; poor language skills after 9 years of language classes, lack of motivation and negative attitude towards language learning, especially L2 - German.

When I ask my students why they asses their language skills so low and why they are not motivated to learn German I get answers such as: "I don't have a talent for German", "German is hard and impossible to learn", "German is boring, we always learn the same things", "I don't have enough vocabulary to express myself", "I had a bad teacher in primary school" , "German is not important for my future life", etc. After the second module of the CAS I realized that the most of those comments refer to MOTIVATION, PLEASURE, REWARD and EXPERIENCE.

When I enrolled in this program, my aim was to learn more about the brain processes involved in learning so that I could help my students to acquire language more efficiently, focusing mainly on improving cognitive aspects such as attention, working memory and reasoning.

However, during the program I have learned that in order for learning to take place, other aspects, such as the affective aspects need to be addressed first. Although the importance of affect is proven to be very important in SLA, as already Krashen (1985) describes the importance of affect in second language learning (SLA) in his Affective Filter

Perspective
Cortica 2023. 2(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

Hypothesis, teachers often seem to ignore this aspect of language learning.

Another important aspect in language learning is the age of the students. My students are adolescents, and this period comes with significant developmental brain changes, which must be taken into account when preparing teaching plans and learning environment. This aim of this project is to adapt my teaching method so that it better corresponds to adolescent learners, taking into account the neuroscientific findings about the adolescent brain.

2. THE ADOLESCENT BRAIN

Teachers often neglect the fact that adolescents are not adults, and that they are undergoing major developmental changes. Adolescence is the transition period from childhood to adulthood between 12 and 21 years of age which involves changes in psychological, social, and physiological development (Vigil, Pilar et al. 2016).

Those changes are reflected in the behavioral patterns that are described as typical for adolescents such as: impulsive, risky behavior, preference for activities which involve immediate reward and preoccupation with what others think of them. According to findings in neuroscience studies these behaviors coincide with the changes in the brain development and can hence help explain some behavior patterns. The brain development theories could lead to better understanding of the adolescent behavior and could potentially contribute to creating interventions which would address certain behaviors, such as risk taking (Blakemore 2018). Moreover, neuroscientific findings on the adolescent brain could also inform education sciences resulting in teaching methods which are more adapted to the cognitive development of the students.

During the adolescence human brain goes through structural and organizational changes, which can be referred to as brain maturation (Dayan, J. & Guillery-Girard, B. 2013, Vigil, Pilar et al. 2016). These changes are especially visible in the prefrontal areas of the brain which is involved in high-level decision making process (Dayan, J. & Guillery-Girard, B. 2013), in the limbic system, which is involved in the regulation of emotions, as well as the pathways which connect these two areas (Arain, M., Haque, M., Johal, L., Mathur, P., Nel, W., Rais, A., Sandhu, R., & Sharma, S. 2013, Rajmohan, V., & Mohandas, E. 2007, Vigil, Pilar et al. 2016.

Brain maturation is characterized by two important mechanisms, synaptic pruning, and growth of the connections between areas of the brain (Dayan, J. & Guillery-Girard, B. 2013, Vigil, Pilar et al. 2016). Synaptic pruning refers to the elimination of synaptic connections which are either not used or are redundant (Santos E., Noggle C.A. 2011). Which synapses will be retained is

Perspective
Cortica 2023. 2(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

determined by our experiences in the world. Repeated experiences will result in strengthening of the synapses, whereas little experience will result in weakening or pruning of the synapses. First significant synaptic pruning occurs between 2.7 - 5 years old, with the child's first experiences in the world (Selemon, L. 2013).

Synapses that are strengthened are myelinated, which makes the synaptic connections faster. Myelination is the process in which gilal cells, olygodendrocites, form myelin sheaths around the axons. Myelin sheaths enable faster transfer of electrical impulses along the axons. Myelination starts after birth and continues through adolescence and adulthood. It is especially prominent in the early years of childhood and adolescence, and it corresponds to cognitive development in those periods of brain maturation (Williamson J.M., Lyons D. A. 2018).

Increased myelination in adolescences is visible in the increase of white matter in the adolescent brain, especially in the prefrontal cortex (Vigil, Pilar et al. 2016). Respectively we can observe a decrease of grey matter, which is made of neurons and synapses. Increase in the white matter, that is myelination, is therefore one of the most important processes in brain maturation which coincides with the development of cognitive abilities, for example faster processing of information (Williamson Jill M., Lyons David A. 2018).

The ability of the brain to create new synapses, strengthen the existing ones and eliminate those that are not used in response to experience is also known as neuroplasticity (Mateos-Aparicio P., Rodríguez-Moreno A. 2019), and it is a phenomenon that occurs all along our lives. However as explained above, we can observe higher neuroplasticity in the period of adolescence (Selemon, L. 2013).

The explanation for the behavior typical for adolescents such as impulsivity, risk taking and immediate reward seeking can be found in the brain changes related to maturation.

One interpretation provided by neurosciences is that since the prefrontal cortex PFC (high-level decision-making process area) is not yet fully mature, adolescents lack cognitive control. On the contrary limbic system, and the reward-punishment systems show earlier maturation and greater activation during the period of adolescence (Dayan, J. & Guillery-Girard, B. 2013).

One neuroscientific theory suggests that the greater activity in the limbic system which is contrasted to the immaturity of the PFC exposes the adolescent brain to the high influence of the limbic system (Dayan, J. & Guillery-Girard, B. 2013). In line with this interpretation, one study showed that

Perspective
Cortica 2023. 2(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

adolescents rely on the emotional regions of the brain during interpersonal interaction and decision making, which could also explain their typical behavior (Arain, M., Haque, M., Johal, L., Mathur, P., Nel, W., Rais, A., Sandhu, R., & Sharma, S. 2013).

Another interpretation suggests that adolescent behavior is a normal and necessary stage in the development of the brain and especially PFC. Through experimentation with impulsive and risky behaviors adolescents are exploring and adapting to the society they live in, developing executive control, emotional regulation, and social cognition (Dayan, J. & Guillery-Girard, B. 2013).

Regardless which theory one decides to explore, research on brain development in adolescence provides valuable knowledge, which can be applied to language teaching and learning tailored specifically to adolescents.

First, having in mind high the activation of the limbic system language teachers should make sure that there is a positive class atmosphere, where each student feels welcome (Arnold, J. 2011). One study with undergraduate students (average 20 years) reports better working memory when the participants were in a happy mood. These results suggest that positive mood improves cognitive functions (Justin Storbeck & Raeya Maswood 2016).

Secondly, teachers should exploit the cognitive potential behind synaptic pruning and increased myelination of the PFC by bringing tasks, which include problem-solving and abstract thinking.

And finally, they should use the development of social cognition to promote learning by encouraging partner and group work in the classroom, as well as outside of the classroom (Mills K. and Anandakumar J. 2020).

3. THE MAIN BRAIN NETWORKS IMPLICATED IN LEARNING

Neuroimaging studies have allowed neurosciences to identify 3 large brain networks, located in specific network hubs. Network hubs are nodes of convergence, where the multimodal signals pertaining to a certain large brain network are integrated (Buckner, R. L., Sepulcre, J., Talukdar, T., Krienen, F. M., Liu, H., Hedden, T., Andrews-Hanna, J. R., Sperling, R. A., & Johnson, K. A. 2009).

Three large brain networks are the central-executive network (CEN), with nodes in dorsolateral prefrontal cortex (DLPFC) and posterior parietal cortex PPC, salience network (SN) located in anterior insula (AI) and anterior cingulate cortex (ACC), and the default mode network (DMN) located in medial PFC, posterior cingulate cortex (PCC), precuneus, and hippocampus (Menon 2010, Ho, T.C., Walker, J.C., Teresi, G.I. et al 2021).

Cortica
www.revue-cortica.net | ISSN : 2813-1940
Perspective
Cortica 2023. 2(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

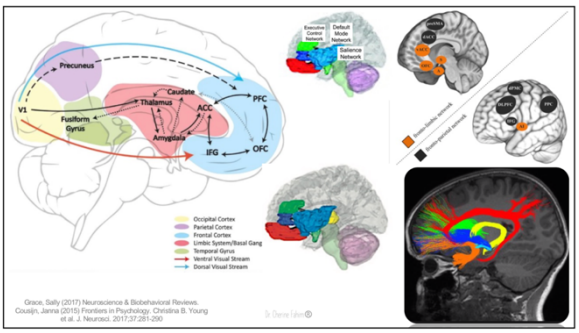

Figure 1: DMN, SN and CEN

Each of these networks is implicated in distinct yet connected processes, which are essential for learning. The CEN sustains working memory, executive attention, and decisions making. The DMN is activated when the brain is at rest, that is when we are not engaged in a specific cognitive task, hence its name “the default mode network”. Neuroimaging studies show that the DMN areas are activated during internal cognitive processes such as remembering personal past events and imagining future events, mentalizing and especially theory of mind (TOM), as well as emotion regulation (Boyatzis et al.2014). All of these function with the ascribed areas is well illustrated in figure 3.

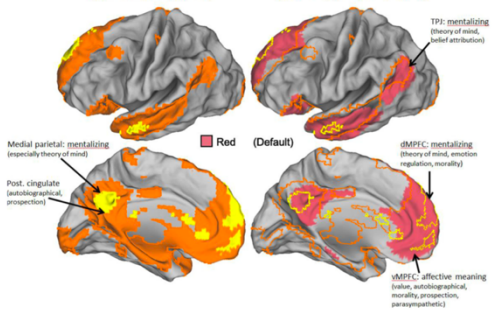

Figure 2: DMN (Boyatzis et al., 2014)

The SN is important for the processing of internal and external stimuli in order to prepare appropriate behavioral response (Menon 2015, Ho, T.C., Walker, J.C., Teresi, G.I. et al 2021). For optimal cognitive processing, good functioning of all three networks, as well as the interaction between them is essential. Especially important is the SN because it serves as a mediator between the CEN and the DMN (Menon V. 2015). Once a stimulus is detected and processed by the SN, either the CEN or the DMN will be activated to further process the information. So in cognitively demanding tasks, such as problem solving, the CEN will be activated whereas the DMN will be suppressed. On the other hand during internally oriented mental processes, such as remembering the past or thinking about the future the DMN will be activated. The SN is also important in detecting salient stimulus that involves emotions and pleasure (Menon V. 2015, Qi, D., Lam, C.L.M., Wong, J.J. et al 2021).

What this means for teaching and learning is that to access cognitive control the affective filter in the SN must be activated. Concretely this means that the input presented to the students must catch their attention in order for them to be motivated to participate in a task.

4. LANGUAGE IN THE BRAIN

In order to better understand how the results of neuroscientific research can contribute to language teaching and learning, it is essential for teachers to have basic knowledge of the

Perspective
Cortica 2023. 2(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

neural basis of language. This section will briefly outline the current model of the neural basis of language, and it will then focus on the importance of the default mode network and the salience network in language processing. The language network in the brain is much more complex than it can be illustrated here, as it contains multiple components of language processing. However, since this paper focuses mainly on the role of the DMN and the SN in language learning, a simple model will suffice to explain the relation between language and the DMN and the SN.

4.1 Neural basis of language

The simple model of language processing in the brain is well known beyond the field of neurosciences. It consists of the Broca's and the Wernicke's areas connected by the arcuate fasciculus.

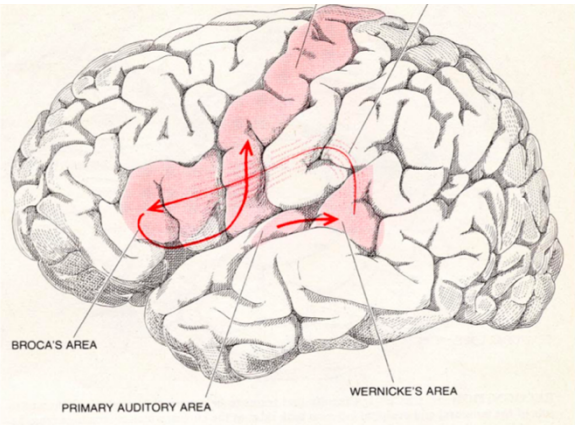

Figure 3: Broca's and Wernicke's areas (Peoppel et al., 2012)

However, thanks to the neuroimaging studies the scientist have discovered, and continue to discover that neural basis of language is a complex interplay of multiple brain networks and subnetworks (Fuji et al. 2016). In order to provide basic knowledge of this complex cognitive phenomenon the dual stream model, as described by Poeppel et al 201, and Fuji et al. 2016 will be presented in this paper. This model suggests that the principal language processing network has two principal pathways, the dorsal and the ventral stream in the dominant hemisphere.

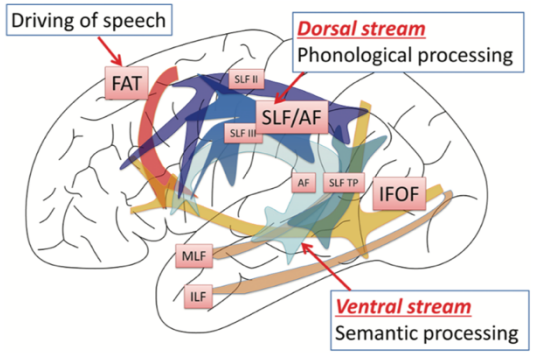

Figure 4: Dual stream model of neural basis of language (M. Fuji et al., 2016)

The dorsal stream is associated with phonological processing via the superior longitudinal fasciculus (SLF,) and the ventral stream is associated with semantic processing via the inferior fronto-occipital fasciculus (iFoF). In addition to the two streams, the model includes another pathway named frontal aslant tract (FAT), which is according to Fuji et al. 2016 "probably associated with initiation and spontaneity of speech" (Fuji et al, 380).

4.2 The role of the Default Mode Network and the Salience Network in language processing

Perspective
Cortica 2023. 2(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

Gordon et al. (2020) found that the DMN can be presented in nine subnetworks. Some of these subnetworks seem to link the DMN to other large brain networks, such as the language network. They found that the Anterior Lateral DMN subnetwork (consisting of the regions of the inferior parietal lobe and cerebellum) are activated by language, as well as social and self-referential processing. Alderson-Day et al. (2015) also found activation in the cerebellum during inner speech tasks. According to them this connection could be explained by the articulatory rehearsal during self-talk, since the cerebellum is connected with the motor cortex (116).

Hertrich et al (2020) suggest that the DMN is connected to the language network via the link with the semantic system in the temporal lobe. The sematic system seems to rely on memory, introspection, and ToM for language processing. Based on their findings they suggest that the DMN is activated in language processing when past experiences need to be recalled in order to create simulations about the future. Similarly, ToM is activated during social interactions when in order to understand the other one must make inferences about his/her intentions.

The link between the SN and language processing lies in the integration of sensory inputs and enabling the activation of other networks that are needed for language processing, such as the DMN and the CEN (Hertrich et al. 2020). The findings reported by Hertrich et al. 2020 suggest that the SN network is relevant on one hand in guiding the narrative comprehension, and on the other hand in detecting atypical elements in the speech, such as accents or prosody.

5. FOUR FILTERS OF ATTENTION AND THE ROLE OF THE SN AND THE DMN IN LEARNING

In order to capture the attention of the students and to enable the activation the CEN, and the DMN teachers can work on are the 4 filters of attention: pleasure, inference, movement and imagination described by Bourassa, M., et al. (2017).

The filter of pleasure is the first filter of attention, it involves the SN and specifically the reward system. If the stimulus or an event is judged as pleasurable or emotionally engaging it will get our attention. This first fast response is guided by the activation of amygdala (Liberzon, I., Phan, K., Decker, L. et al 2003) and the activation of the reward system and the release of dopamine. As mentioned in the previous sections, it is essential that the learning atmosphere is positive and that students feel appreciated and welcome in the classroom (Arnold, J. 2011). Especially because amygdala is activated in both cases, when the stimulus or an event is emotionally positive or negative, teachers should be careful not to negatively influence the students (Liberzon, I., Phan, K., Decker, L. et al 2003). To further promote this filter,

Perspective
Cortica 2023. 2(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

teachers can work with the learning input, that is novel, surprising and which provokes an emotion in adolescents.

Once the attention is activated through the first filter, we move on to the filter of inference. This filter engages the DMN and our autobiographical memory by relying on it to create hypothesis about the salient stimulus or the event. Our expectations are based on our experiences. Here we can introduce the notion of somatic-marker hypothesis by Damasio (1994). Damasio's theory suggests that we learn how to react to situations through our experiences, and that that memory is saved for future reactions. So when we recall past events or imagine the future we will activate that memory (Silke M. Müller, Magnus Liebherr, Elisa Wegmann, Matthias Brand 2022). Teachers could promote this filter by creating tasks which enable the students to test their predictions and become aware that different predictions are also possible. Presenting them cognitive biases and discussing them with the students could be one such task.

The third movement filter is activated when the stimulus or an event has been evaluated as positive and inferences about it can be made. This filter once again evaluates which movement is appropriate for the given stimulus or an event based on the inferences made in the second filter. In this step we adapt our reaction by looking back at our inferences and past reactions, as well as those of others. Here we can rely on mirror neurons to replay the actions we have done in the past and to anticipate the actions of others. This filter involves the activation of the DMN and the CEN.

To promote this filter teachers could do formative tests and then give feedback to the students encouraging them to recognize their errors and encourage them to apply that knowledge to the next task.

And lastly the imagination filter, which involves the activation of the DMN is responsible for anticipating multiple reactions to a given stimulus or an event.

6. PROJECT: ACTIVATION OF THE SN AND THE DMN VIA THE 4 FILTERS OF ATTENTION IN LANGUAGE TEACHING AND LEARNING

Based on the review of the findings about the adolescent brain and the role the limbic system in engaging the students in the learning process, my aim was to increase the overall motivation of the students to participate in my classes, and indirectly increase their motivation to actively engage in their learning process. In order to achieve that I first adapted my overall teaching technique and then created tasks which aimed to grab and maintain the attention of the students. In order to work on the attention and the motivation I relied on the activation of the 4 filters of attention and the SN and the DMN.

Perspective
Cortica 2023. *2*(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

This section will first describe the conditions in which this project was developed, it will then show how the 4 filters framework was applied to teaching L2 and L3, and finally it will present the findings in the form of the teacher self-assessment and student feedback.

6.1 School – class conditions

The project took place at the vocational school of applied arts, eikon in Fribourg, where I teach German L2 and English L3. The school offers a training for interactive media designers in two programs. The first program consists of general knowledge classes and in-school vocational training, and it enables the students to obtain a federal diploma of vocational education and training. The second program consists of in-school vocational training and academic knowledge classes, and it is hence also called maturity program. This program leads to the federal vocational baccalaureate, and it enables the students to continue their studies at a university of applied arts.

In order to be accepted to the second program students must present adequate school grades or pass an entrance test. This procedure aims to ensure that only the students who have prerequisite knowledge and are motivated to take academic classes enter the program.

The maturity program is cognitively highly demanding, since all academic classes take place during 1 and a half days a week.

The class chosen for the project is 1st year maturity program, consisting of 19 students (mixed female and male). The age range is between 16 and 19 years. Apart from 2 students all students entered the program without the entrance test, which means they already had high grades in the secondary school or the previous training.

I chose this class for three reasons. Firstly, I did not know the students, so I was not biased. Secondly, the students did not know me as a teacher, which meant they were not biased either. And lastly, choosing the first year class meant I could adapt the teaching plan to my project.

I teach L2 German as well as L3 English in this class, and for each subject I have one lesson of 45 minutes per week. As a consequence, I had a total of 7 lessons per subject with the class. Since I have little time with the students, I didn't distinguish between L2 and L3 classes, I decided to apply the same strategies to both L2 and L3 classes.

6.2 Setting the goals

During the first lesson in both subjects I usually present classroom rules, the material, and the teaching program. I also tell the students that I speak either only English or only German, depending which class I am teaching.

Perspective
Cortica 2023. *2*(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

As a result of what I have learned during the classes in the CAS this previous year, I decided to add three things to this introduction. First, I decided to clarify with the students their goals. Orally, I elicited responses to the following two questions, and I wrote the answers on the whiteboard.

a) Why did you choose the maturity program?

b) Why do you need to attend and pass language classes?

The students' answers are summarized in the table below:

a) why did you chose the maturity program?	b) why do you need to attend and pass language classes?
I need the diploma because I want to continue my studies at the university of applied arts or an art school. I think I will have better chances at finding a job.	L2 and L3 are a part of the maturity program, I have to attend these classes. In order to obtain the federal vocational baccalaureate I need to pass the final exams in the third year, and I need to have the knowledge to pass the exams. Foreign languages are important in my job. (interactive media designer) I want to do an internship or find a job in an English speaking country.

The objective behind this step was to clarify and set the common goals with the students. Consequently, I wanted to actively engage them in the long-term learning process by providing transparent and clear goals, and in this way activate their attention and motivation. This approach was inspired by the lectures given by Dr. Squillaci (CAS 2022), during which she showed how setting clear, transparent goals can contribute to better motivation. Also by letting them define their long-term goals (within given conditions) I aimed at attributing subjective value to engaging behavior in my classes. Berkman (2018) points to the importance of subjective value of actions for maintaining the goal and the behavior which will lead to it. After the Module 2 of the CAS last year, I had a similar discussion with a third year class and the answers they provided were the same, hence I anticipated the answers the students gave me this year.

Second step in engaging the students in the learning process was to let them describe their learning experience and their needs and wishes for the learning process in my classes. Here I asked them to tell me about the good and bad practices in L2 and L3 classes they had in the secondary school. Again I was writing the answers on the whiteboard as they were sharing their experiences.

The students' answers are summarized in the table below:

Good practice	Bad practice
Games (vocabulary, grammar) Teacher gives thematic vocabulary lists to learn in advance and practice in class Tables for revision	Long vocabulary lists to learn by heart Vocabulary not practiced in class Only grammar Difficult or too simple tasks

Perspective
Cortica 2023. *2*(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

Reading fun texts and books Formative tests Tests that correspond to the objectives Speaking exercises (practical language) Clear objectives before each class Partner and group work Debates (includes learning vocabulary to be able to participate in debates) Teacher in a good mood	Tests with a lot of content Frontal instruction with no student engagement Teacher who doesn't speak the target language in class Teacher always angry

Interesting here is that the students identified some of the best teaching strategies according to Hattie, such as clear objectives and instructions and the importance of feedback for the learning progress (Tokuhama 2014). Also, some factors which appeal to the adolescent brain are illustrated in the good practice list. For example, playing games might reflect the need for the activation of the reward system for learning, as well as the activation of pleasure and hence the exploitation of the highly active limbic system in general. Learning games, especially grammar games activate the reward system, because the students are playing to win and hence the instant reward of wining motivates them to play. Also, they are playing with and in front of their peers, which increases their motivation to win the game.

Another important factor for the students seems to be the mood of the teacher, as indicated in their answers. Most of them mentioned they were more eager to participate in the classes, when the teacher was in a good mood. Here again the activation of motivation and attention via the limbic system is important. Both Tokuhama 2014 and Bourassa 2017 emphasize the importance of the positive classroom climate for motivation.

Also notable is the wish for partner and group work, which might correspond to the development of social cognition at this stage in brain maturation. And finally, an element which I found surprising is the wish to participate in debates, which might correspond to the maturation of the prefrontal cortex, and hence the need for higher order thinking.

I never do debates in my classes, because I think students don't have enough vocabulary and hence, they will feel frustrated if they can't express their opinion. However, a solution to that problem (as suggested by the students) would be to pre-teach the vocabulary they will use in the debate.

The purpose of this step was to give the students a certain degree of autonomy in the learning process on a larger scale. The general conditions, such as the teaching program, the number of lessons and the basic school behavior rules, are predefined. However, the students can participate in choosing the teaching and learning strategies, which best suit them based on their learning experience. By letting the students describe the good practice teaching and learning strategies, I aimed to give them the feeling of competence and inclusion. This approach was

Perspective
Cortica 2023. *2*(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

suggested by Dr. Jean-Luc Gurtner in Module 4, in which he talked about the self-determination theory developed by Deci and Ryan 1985 (CAS 2022). According to the self-determination theory, autonomy, competence, and inclusion are the key factors for motivation.

Following the discussion, I suggested to apply the good practice examples they gave me in the planning of my lessons. The effect of these three additional steps was instantly visible in the positive attitude of the students.

Taking into account the limited time I had with the students, I had to find a suitable way to measure the effect of my approach. As described in the intention of my project, my aim was to increase the overall motivation of the students to participate in my classes, and indirectly increase the motivation to actively engage them in their learning process. Then I wanted to create tasks which will grab and maintain their attention.

In order to meaningfully measure these two things, I decided to give the students a short questionnaire to evaluate my teaching methods and their learning motivation before the autumn holidays. The questionnaire and the results will be discussed in section 6.4. Additionally, I observed the students' behavior and took notes regarding the attention and the motivation they exhibited while performing the activities.

6.3 Teaching strategies and activities

6.3.1 Teaching strategies and classroom climate

First thing I implemented in my lessons was to come to class with a smile on my face and to tell my students that I am happy to be working with them that day.

This step was inspired by Dr. Myriam Squillaci's lecture, during which I was impressed by how just a smile and showing pleasure in being in the space with the participants can activate motivation and attention. Studies show that if the stimulus or an event is judged as pleasurable or emotionally engaging it will get our attention. Bourassa 2017, as well as Tokuhama 2014 suggest that positive teacher behavior significantly contributes to students' attention in class. Also coupling positive emotions with school learning environment might contributed to overall motivation to participate in class activities. This is especially important for L2 German, since most students report that they associate learning German with negative emotions.

Next step was to show the students the objectives at the beginning of each lesson. Bourassa 2017 suggests that this approach also activates the SN, by removing the negative emotions of the unknown, potentially unpleasurable events already at the beginning. Similarly, Tokuhama 2014 shows that to activate the attention, the students

Perspective
Cortica 2023. 2(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

need to know what their attention is directed to, i.e., what the goal is.

With these two simple steps I aimed to work on the filter of pleasure already at the beginning of the lesson. I then tried to train the reward circuit by starting each lesson on a positive note and by presenting the objectives. In order to avoid repetition, I varied how I present the objectives, and how I start the lesson.

6.3.2 Introduction activities – input and revision

Once I had the attention of the students the objective was to maintain it before I arrive to the cognitively challenging tasks, which required the activation of the CEN. Here I relied on maintaining the SN active by working further on the filter of pleasure. I also added the filter of inference and hence the activation of the DMN. To activate the filter of inference I aimed to elicit what the students already know about the topic, especially concerning grammar (grammar topics seen in the secondary school are revised in the first semester in L2 and L3) or vocabulary. Here I tried to coactivate the first and the second filter by creating revision games.

I chose to use the learning applications Kahoot and Quizlet live, which I have already used in my other classes. In my other classes I observed that the students enjoy playing these games and that they are almost instantly active when I suggest to play them. I thought I would benefit the most from them to maintain the attention and the motivation, by using them at the beginning of the lesson, as either revision or as an introduction to the topic. These applications also aid to activate the first and the second filter by increasing the wavelength via the lively music in the background, limited response time, and the vivid colors on the screen (Bourassa 2017). I varied the social form for this exercise, so sometimes the students played alone again each other, and other times they played in pairs or in teams. In this way I addressed their wish to work in pairs and in groups.

Another exercise I did at the beginning of the lesson was to give the students a task in which they need to find the mistakes in either grammatically or contextually incorrect sentences. I varied easier and more complicated sentences, to enable the feeling of competence (important for self-determination and hence maintaining the motivation), and to show them that they do not come to my class tabula rasa, but that they already have the knowledge they can use to advance in their learning process. The aim here was to activate the filter of inference and hence the DMN.

I also adapted this exercise to train metacognition. In the extension of the exercise, I divided the students into pairs and gave each pair a set of sentences, out of which some contained mistakes. They had 3 subtasks here; to find the mistakes, correct

Perspective
Cortica 2023. 2(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

them and explain the rule behind the correction.

I had two sets of sentences, which meant that every other pair had a different set. After they finished, I gave them the answer sheet, told them to check and ask me if they don't understand something. Then I separated the pairs and mixed the pairs so that each new pair contained 1 expert from the previous pair. They then had the task to explain each other the problem and how they solved it.

This exercise is called expert group exercise, and the objective here is that each pair/group solves the task and becomes an "expert" for that problem. Subsequently, pairs are mixed so that each pair contains the expert from the previous pair.

This exercise was also used in reading and listening inputs. Here students had to read a text or listen to a podcast and get familiar with the topic (guided by my questions), and then report it to the other group, which asked specific questions about the topic (again guided by me).

6.3.3 Central activities – input processing and consolidation

For the central, longer activities my principal aim was to activate the filters of movement and imagination, and hence to continue working on the activation of the DMN. In this step I prepared 2 exercises for my English class and 1 exercise for my German class.

For the first exercise I took the students wish for debates into account and I prepared a speaking lesson centered around the debate regarding the topic "Stereotypes". The topic is given in the cantonal teaching plan for the 1st year, which meant I could not change it.

First, I had to prepare the conditions (activation of the first and the second filter) by giving the students the thematic vocabulary list 3 weeks in advance and instructing them to learn it. I then practiced the vocabulary in class at the beginning of the subsequent 2 lessons. I used the Kahoot game to practice the vocabulary and enable the students to receive direct feedback on how many words they've learned and how many they still had to learn. In this way they could prepare for the cognitively more challenging task.

The topic "Stereotypes" is a common topic, which doesn't require additional general knowledge. Relying on the experience from other classes I anticipated that the students will know what stereotypes are, and that the most of them will have personal experience with them. So instead of giving students an input in a form of a text about stereotypes I decided to exploit their experiences to activate the filters 2, 3 and 4. This means that the exercise was centered on students' experiences, Tokuhama 2014 suggest that student-centered exercises activate their

Perspective
Cortica 2023. 2(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

attention. This might be due to the activation of the second filter and the DMN, via the need to draw on the autobiographical memory.

In order to make sure everybody understands what stereotypes are, I took 5 minutes to introduce the topic by projecting a joke about stereotypes (also activation of the filter 1), and by shortly discussing if the students thought the joke was true or not. To facilitate the comprehension, I projected the joke with the corresponding image illustrating the joke. The joke and the image are shown below.

"HEAVEN is where: The police are British, The chefs Italian, The mechanics are German, and it's all organized by the Swiss.

HELL is where: The police are German, The chefs are British, The mechanics are French, and it's all organized by the Italians!

Consequently, I divided the debate in 3 steps:

Step 1 Pairs	Students share their experiences regarding stereotypes in pairs.
Step 2 Whole class	Class discussion about positive and negative aspects of stereotypes. Results of the discussion are written on the whiteboard.
Step 3 Teams	Debate in teams of 3 students. Team 1 advocates positive aspects and team two advocates negative aspects. The goal is to convince the other team that stereotypes are either good or bad.

For the second exercise in English, I prepared a creative writing exercise, following a story we read in class, "All Summer in a Day" by Ray Bradbury. The story is a fiction piece about a life on Venus, where the sun comes out once every seven years. The plot is centered around a girl named Margot, who is the only one in her class who saw the sun because she used to live on Earth. She tells her classmates about the beauty of the sun, but they don't believe her, and they mock her. As the class prepares to go out and see the sun, her classmates lock her in a closet in the classroom and Margot misses to see the sun again. Her classmates feel sorry for locking her up, and they rush to release her, and this is how the story ends.

The students very moved by this story, as it deals with injustice, which is a topic which adolescent learners are usually motivated to discuss. However, drawing on their personal experiences here can lead to negative emotions, and hence the activation of amygdala, which would result in the decrease of attention and motivation.

Nevertheless, I wanted to enable them to process the story and to express their opinion and their feelings about the injustice Margot suffered. So, I prepared an exercise in which they could take on the role of Margot and

speak from her perspective. The aim here was to work on the activation of the DMN and the filters 3 and 4, by offering the students a safe space in which they could engage in introspection and activate the TOM system.

I also offered the students a certain degree of autonomy, by letting them choose between 2 task options.

The exercise I gave the students for this story is shown here below.

Choose 1 option.

a) Create a dialogue

What would Margot say to her classmates and teachers now that she has been freed? How would they respond to her? Write a dialogue that begins at the moment Margot walks out of the closet.

b) Write a letter

Imagine you are Margot and write a letter to your friend on Earth about what happened.

The third exercise was prepared for my German class, in which it is more challenging to motivate the students and to maintain the motivation. The reason for this is the strong negative attitudes towards learning L2 German in the school setting, which result from many different factors, such as previous negative learning experience which lead to the somatic marker of fear, collective negative attitudes transferred to the students by their surrounding (German is a difficult language and I cannot learn it), etc.

Therefore, my primary aim in the German class is to couple the learning experience with positive emotions, such as pleasure and enjoyment, and to motivate the students to participate in the learning process.

The exercise I created is with this objective in mind is called “My funny family portrait”.

In the previous lessons I have worked on the thematic vocabulary for the topic “Descriptions”. I applied the strategy described in the section 6.2 to practice the vocabulary in class. Additionally, the students wrote 1 formative test consisting of translation tasks and vocabulary in use tasks.

To activate the filters 1 and 2 I opened the lesson by telling the students I wanted to share with them a funny article I read during the weekend. I showed them funny family portraits that were in the article, and I asked them to guess the topic of lesson.

The photos made the students laugh almost instantly, and many of them raised their hands to say that the topic of the lesson was “My family”. I managed to grab their attention.

I hypothesize that the negative attitude towards German has for many students indeed become a somatic marker, and that

Perspective
Cortica 2023. *2*(1), 10-29
https://doi.org/10.26034/cortica.2022.3344

just being in a German class activates the amygdala and blocks the attention. I believe that the best way to counteract the activation of amygdala and the negative emotions, and hopefully to recondition the negative attitude into positive attitude is by training the dopaminergic circuit through humor. Humor has an element of surprise in it, which seems to activate the attention.

After the aforementioned introduction, I told the students that the objective is to practice the vocabulary they have been learning, by describing their own funny family portrait. I asked them to look through the photos in the phone and find a funny family portrait, or to draw one in case they didn't have the photo in their phones. The task was to described the family members and the situation in which the portrait took place. In this step I aimed to activate the DMN via the episodic memory. Also, funny family portraits usually stem from emotionally pleasing past memories, hence remembering one such event might contribute further to the activation of the filter of pleasure.

The activities described in this section present a few examples of how I tried to adapt my teaching according to the knowledge I have acquired in the CAS. Additional exercises have been developed and used in other classes, but since I wasn't as consistent as I was in the class I chose to observe and evaluate, I did not include them in the project.

6.4 Teaching evaluation

As mentioned at the beginning of the section 6, to know if the students were motivated to participate in my classes, I asked the students to evaluate the first 7 weeks of teaching with the simple questionnaire shown below, with summarized answers from the students. The students did not need to write their names unless they wanted to.

	+	-	Suggestions/ remarks
Classroom climate	Teacher positive and smiling, teacher funny I like coming to this class		
Activities	Games Revision at the beginning Objectives presented at the beginning Formative tests Good rhythm, not too fast and not to slow	Teacher didn't correct the grammar table we did in groups, so I learned wrong Objectives sometimes not clear	
My motivation and engagement	I am motivated to learn German I am motivated to come to this class I feel confident I am not afraid of German I don't like languages but I still	Not enough vocabulary to participate I don't work at home to prepare the vocabulary	I should study more at home

	participate in the class		

The answers the students provided in the table do indeed show that the students are generally motivated to come to the classes and to participate in the classes. They evaluate the classroom climate as positive, and here they indicate teacher positive behavior as an important factor. Regarding the classroom activities the most prominent are the games, revision, objectives, and the formative tests. One student wrote that the objectives are sometimes not clear, that could be due to the fact that they are written in German and in English only. For the students who don't have enough vocabulary, it could be hard to understand the objectives. Additional to the objectives in L2 and L2 I could offer the translation in French. Important remark, which I have missed in class is that I didn't give adequate direct feedback to the group work students did in class, which resulted in students learning the rule wrong. Enabling enough time to give direct feedback is an aspect I intend on working in the future.

The comments regarding the self-assessment of the students also point to increased motivation to engage in the learning process. I found the last two comments in the + column especially interesting. The aim was to take away the fear of coming to the German class, and for some students this seems to be the case. Some students acknowledge the fact that they don't prepare for the classes at home, which prevents them from participating. This insight is also very important, because they recognize that they are responsible for their learning process.

7. DISCUSSION AND CONCLUSION

The primary aim of this project was to apply the basic knowledge about the two brain networks, the SN and the DMN and their importance in the learning process to activate and maintain the students' attention and motivation. The feedback I received in the evaluation in the 6.4 section suggests that the students are indeed motivated to participate in my classes. However, since there is no feedback concerning the attention, I cannot make inferences about it. One big limitation of this project is the questionnaire, which was too open and did not address the aspect of attention.

Another limitation of this project is that I cannot compare the motivation and the attention at the beginning versus at the end of the project. As a result, I cannot tell if the high motivation is indeed due to my teaching methods.

Finally, the time of the project was too short to make any meaningful inferences about the success of the teaching techniques, which is why I intend on continuing this project until the end of this school year and repeat the questionnaire with more precise questions.

References

Alderson-Day, B., Weis, S., McCarthy-Jones, S., Moseley, P., Smailes, D., & Fernyhough, C. (2016). The brain's conversation with

itself: neural substrates of dialogic inner speech. *Social cognitive and affective neuroscience*, *11*(1), 110–120. https://doi.org/10.1093/scan/nsv094

Arain, M., Haque, M., Johal, L., Mathur, P., Nel, W., Rais, A., Sandhu, R., & Sharma, S. (2013). Maturation of the adolescent brain. *Neuropsychiatric disease and treatment*, *9*, 449–461. https://doi.org/10.2147/NDT.S39776

Arnold, Jane. 2011. Attention to Affect in Language Learning. *Anglistik. International Journal of English Studies,* 22/1,11-22.

Blakemore Doubleday Sarah-Jayne (2018). *Inventing Ourselves: The Secret Life of the Teenage Brain*. http://dx.doi.org/10.1016/S1474-4422

Berkman E. T. (2018). The Neuroscience of Goals and Behavior Change. *Consulting psychology journal*, *70*(1), 28–44. https://doi.org/10.1037/cpb0000094

Brandman, T., Malach, R. & Simony, E. (2021). The surprising role of the default mode network in naturalistic perception. *Commun Biol* **4**, 79 https://doi.org/10.1038/s42003-020-01602-z

Bourassa, M, Menot-Martin, M. et Philion, R. (2017). *Neurosciences et éducation. Pour apprendre et accompagner*. Bruxelles, Belgique : De Boeck

Boyatzis, Richard & Rochford, Kylie & Jack, Anthony. (2014). Antagonistic Neural Networks Underlying Differentiated Leadership Roles. Frontiers in human neuroscience. 8. 114. 10.3389/fnhum.2014.00114.

Buckner, R. L., Sepulcre, J., Talukdar, T., Krienen, F. M., Liu, H., Hedden, T., Andrews-Hanna, J. R., Sperling, R. A., & Johnson, K. A. (2009). Cortical hubs revealed by intrinsic functional connectivity: mapping, assessment of stability, and relation to Alzheimer's disease. *The Journal of neuroscience : the official journal of the Society for Neuroscience*, *29*(6), 1860–1873. https://doi.org/10.1523/JNEUROSCI.5062-08.2009

Casey, B. J., Getz, S., & Galvan, A. (2008). The adolescent brain. *Developmental review: DR*, *28*(1), 62–77. https://doi.org/10.1016/j.dr.2007.08.003

Chen, A. C., Oathes, D. J., Chang, C., Bradley, T., Zhou, Z. W., Williams, L. M., Glover, G. H., Deisseroth, K., & Etkin, A. (2013). Causal interactions between fronto-parietal central executive and default-mode networks in humans. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(49), 19944–19949. https://doi.org/10.1073/pnas.1311772110

Dayan, J. & Guillery-Girard, B. (2013). Adolescent Behaviors and Cerebral Development: Psychoanalysis and the Neurosciences», *Adolescence /Monographs* II in Eng (Special issue), p. 47-80

Fahim, C. (2022). PRESENCE enracinée dans le cerveau par une prédisposition génétique et tissée par l'épigénétique. Cortica 1(1) 1-3 https://doi.org/10.26034/cortica.2022.1779

Fujii, M., Maesawa, S., Ishiai, S., Iwami, K., Futamura, M., & Saito, K. (2016). Neural Basis of Language: An Overview of An Evolving Model. *Neurologia medico-chirurgica*, *56*(7), 379–386. https://doi.org/10.2176/nmc.ra.2016-0014

Gordon EM, Laumann TO, Marek S, Raut RV, Gratton C, Newbold DJ, Greene DJ, Coalson RS, Snyder AZ, Schlaggar BL et al. (2020). Default-mode network streams for coupling to language and control systems. Proc Natl Acad Sci. 117:17308–17319.

Gurtner J- L. (2022). Chap.: Motivation. CAS en Neurosciences de l'éducation: fondements et pratiques 2021-2022.

Hertrich Ingo, Dietrich Susanne, Ackermann Hermann (2020). The Margins of the Language Network in the Brain. Frontiers in Communication 5. https://www.frontiersin.org/articles/10.3389/fcomm.2020.519955 doi:10.3389/fcomm.2020.519955

Ho, T.C., Walker, J.C., Teresi, G.I. *et al.* (2021). Default mode and salience network alterations in suicidal and non-suicidal self-injurious thoughts and behaviors in adolescents with depression. *Transl Psychiatry* 11, 38 https://doi.org/10.1038/s41398-020-01103-x

Jiang S, Wang S, Wan X (2022) Metacognition and mentalizing are associated with distinct neural representations of decision uncertainty. PLOS Biology 20(5): e3001301. https://doi.org/10.1371/journal.pbio.3001301

Krashen, S. D. (1985). The input hypothesis: Issues and implications. London: Longman.

Kolb, B., & Gibb, R. (2011). Brain plasticity and behaviour in the developing brain. *Journal of the Canadian Academy of Child and Adolescent Psychiatry = Journal de l'Academie canadienne de psychiatrie de l'enfant et de l'adolescent*, *20*(4), 265–276.

Liberzon, I., Phan, K., Decker, L. *et al.* (2003). Extended Amygdala and Emotional Salience: A PET Activation Study of Positive and Negative Affect. *Neuropsychopharmacol* 28, 726-733. https://doi.org/10.1038/sj.npp.1300113

Li, P., Jeong, H. The social brain of language: grounding second language learning in social interaction. *npj Sci. Learn.* **5**, 8 (2020). https://doi.org/10.1038/s41539-020-0068-7

Liljeholm, M., & O'Doherty, J. P. (2012). Contributions of the striatum to learning, motivation, and performance: an associative account. *Trends in cognitive sciences*, *16*(9), 467–475. https://doi.org/10.1016/j.tics.2012.07.007

Mateos-Aparicio Pedro, Rodríguez-Moreno Antonio (2019). The Impact of Studying Brain Plasticity. Frontiers in Cellular Neuroscience, 13. https://www.frontiersin.org/article/10.3389/fncel.2019.00066

Menon V. (2015). Salience Network. In: Arthur W. Toga, editor. Brain Mapping: An Encyclopedic Reference, vol. 2, pp. 597-611. Academic Press: Elsevier.

Mills K and Anandakumar J (2020). The Adolescent Brain Is Literally Awesome. Front. Young Minds. 8:75. doi: 10.3389/frym.2020.00075

Muñoz José M. (2017). Somatic Markers, Rhetoric, and Post-truth. *Frontiers in Psychology*, 8. https://www.frontiersin.org/articles/10.3389/fpsyg.2017.01273

Qi, D., Lam, C.L.M., Wong, J.J. *et al.* (2021). Positive affect is inversely related to the salience and emotion network's connectivity. *Brain Imaging and Behavior* 15, 2031–2039. https://doi.org/10.1007/s11682-020-00397-1

Poeppel D, Emmorey K, Hickok G, Pylkkänen L (2012) Towards a new neurobiology of language. J Neurosci **32**: 14125–14131. doi:10.1523/JNEUROSCI.3244-12.2012 pmid:23055482

Rajmohan, V., & Mohandas, E. (2007). The limbic system. *Indian journal of psychiatry*, *49*(2), 132–139. https://doi.org/10.4103/0019-5545.33264

Sakai J. (2020). Core Concept: How synaptic pruning shapes neural wiring during development and, possibly, in disease. *Proceedings of the National Academy of Sciences of the United States of America*, *117*(28), 16096–16099. https://doi.org/10.1073/pnas.2010281117

Salvi, C., Bricolo, E., Franconeri, S. L., Kounios, J., & Beeman, M. (2015). Sudden insight is associated with shutting out visual inputs. *Psychonomic bulletin & review*, *22*(6), 1814–1819. https://doi.org/10.3758/s13423-015-0845-0

Santos E., Noggle C.A. (2011) Synaptic Pruning. In: Goldstein S., Naglieri J.A. (eds) Encyclopedia of Child Behavior and Development. Springer, Boston, MA. https://doi.org/10.1007/978-0-387-79061-9_2856

Selemon, L. (2013). A role for synaptic plasticity in the adolescent development of executive function. *Transl Psychiatry* 3, e238 https://doi.org/10.1038/tp.2013.7

Shan, X., Liao, R., Ou, Y., Ding, Y., Liu, F., Chen, J., Zhao, J., Guo, W., & He, Y. (2020). Metacognitive Training Modulates Default-Mode Network Homogeneity During 8-Week Olanzapine Treatment in Patients With Schizophrenia. *Frontiers in psychiatry*, *11*, 234. https://doi.org/10.3389/fpsyt.2020.00234

Stiles J. (2017). Principles of brain development. *Wiley interdisciplinary reviews. Cognitive science*, *8*(1-2), 10.1002/wcs.1402. https://doi.org/10.1002/wcs.1402

Squillaci M. (2022). Les défis de la classe hétérogène. Apports des neurosciences à l'enseignement. CAS en Neurosciences de l'éducation: fondements et pratiques 2021-2022.

Tokuhama-Espinosa, Tracey. (2014). Making classrooms better : 50 practical applications of mind, brain, and education science. New York, N.Y. :W.W Norton & Company, Inc.,

Vigil, P., Del Río, J. P., Carrera, B., ArÁnguiz, F. C., Rioseco, H., & Cortés, M. E. (2016). Influence of sex steroid hormones on the adolescent brain and behavior: An update. *The Linacre quarterly*, *83*(3), 308–329. https://doi.org/10.1080/00243639.2016.1211863

Williamson J.M., Lyons D. A. (2018). Myelin Dynamics Throughout Life: An Ever-Changing Landscape? Frontiers in Cellular Neuroscience,12. https://www.frontiersin.org/article/10.3389/fncel.2018.00424

https://www.eda.admin.ch/aboutswitzerland/en/home/bildung-wissenschaft/bildung/berufsbildung-lehre.html