Neural foundations of creativity in foreign language acquisition

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This article focuses on the subject of several independent sciences, in particular linguistics and language didactics, as well as interdisciplinary research: the acquisition of creative foreign language competences. Whereas creativity is a very complex concept and very difficult to describe, it is most commonly explained with the help of examples. Due to recent technological progress, imaging methods are now able to show where creative activity, especially linguistic creativity, is located in the human brain and where it might possibly originate. The following article presents recently collected data from language acquisition-related neuroscientific studies in contrast to existing findings of language acquisition research as well as implicit language acquisition. Subsequently, all findings are used in order to draw conclusions about general as well as specific language didactics. In addition, a second goal is the demystification of apparently unproductive and unfocused states, which are wrongly stigmatised and unfairly seen as wasted time in institutionalised contexts. The results of this article, therefore, try to make those situations available again for goal-oriented foreign language acquisition.

KEYWORDS: *neuroscience, language acquisition, implicit language learning, mind-wandering, Attention Mode Network, Default Mode Network*

1. INTRODUCTION

Since the start of this millennium, anecdotal evidence of the onset of creative ideas has shown that problem solving, in other words, finding creative solutions for a specific problem, often takes place after relinquishing the effort to solve them, when the mind is seemingly wandering. This effect is frequently said to be related to implicit and automatic everyday actions, like walking, driving, riding a bike, showering, etc. Even Einstein and Newton claimed that important moments of their inspiration arose while they were engaged in thoughts and activities that did not consciously aim at solving the problem they had been trying to solve before (Asimov, 1971).

Creativity has to do with the imagination of what will happen in the near future. Even five-year-olds invent imaginary friends, teenagers can imagine being in love, and adults plan career

advancement, home purchase, or a trip around the world. People have this type of imagination and use it constantly in everyday life. However, it is limited: something that is far removed from people's temporal or spatial reality – say, the world in the year 2500, or what it would be like to live on the moon – is often difficult for them to imagine. Interestingly, it seems to be the same for foreign language acquisition in non-instructional contexts or institutionalised language-learning settings where concentration is a necessary mental predisposition to process foreign language material and to know, how and why to say what to whom. In any foreign language, far more words and structures that have been learned implicitly build up a non-testable balance of linguistic, pragmatic and communicative competence.

Sometimes creative language production and performances, unbelievable even for the foreign language learners themselves, occur when concentration fades out and positive psychological conditions like, e.g. non-restriction or lacking time pressure lead to fluency and creative language use. The question is, how can that be, since non-focused mental states are frequently looked upon as dysfunctional ones?

2. MATERIAL AND METHODS

The research is conducted within the framework of neuro-scientific research. It explores the role of AMN (Attention Mode Networks) and DMN (Default Mode Networks), describes their key features and applies them to the process of implicit language acquisition through 'mind-wandering'. It also uses Bloom's taxonomy, showing a hierarchy of educational objectives. The paper includes diagrams of brain activity and tables of educational objectives and neuronal networks as applied to language learning in the research.

3. THEORETICAL BACKGROUND

3.1 Creativity and foreign language acquisition

Language acquisition is a highly complex and also a creative process. It is affected by social and cultural environment inside and outside the language contexts, by the structure of the native and target languages, by the length of exposure to the target languages, by the regular use of the languages, personal characteristics and experiences, and also the type or method of instruction, when explicitly learned, e.g. form-focused or meaning-focused.

Creating growth in language competences and developing creative skills in foreign languages as well as in the mother tongue requires specific preconditions. In many cases, it is associated with communicative interaction, playing, fantasy, collaboration or experimentation. Bloom's taxonomy provides a helpful and orientating hierarchy of several levels of complexity. Besides all provided definitions and theoretical frameworks of the scientific concept of creativity, it

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offers a classification context, specifically locating creativity above all former learning objectives (Figure 1).

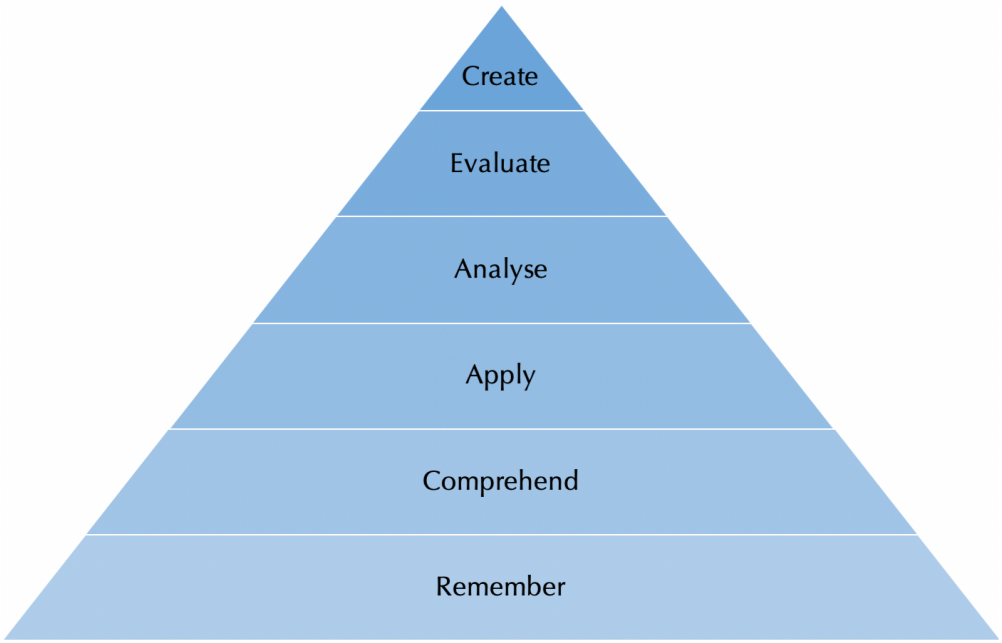

Figure 1. Bloom's taxonomy (adapted and adjusted from Anderson & Krathwohl, 2001)

For instance, it includes knowledge as the remembering of previously learned language material on the lowest-level of language acquisition. Comprehension on the second level, then, means the ability to grasp the *meaning* of language material. Application, the ability to use learned material in new and concrete situations, follows that. The ability to analyse and break down language material into its components constitutes the fourth place of the hierarchy. Evaluating the compiled language material for a specific purpose forms the fifth stage. Finally, blending that material together to form something new can then be called *creativity* and makes up for the final part of Bloom's taxonomy. Combining speech parts, producing new sentences, articulating freely and authoring texts are only a few selected examples of creative language competences. Nevertheless, the taxonomy is interdependent, and each stage is necessary for language acquisition to take place. Creativity without knowledge is not possible. With a closer look at language acquisition, this means that creative speech production without knowing words or grammar rules seems to be impossible.

3.2 Dynamic thinking process without a stimulus: Mind-wandering

Mind-wandering is a dynamic process of changes

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in mental states (Böttger, 2018). This childlike experience, also known as 'daydreaming' or, more theoretically, 'stimulus-independent thoughts', refers to times when the mind strays from a situation of full concentration, e.g. on solving a problem, in favour of unrelated thoughts. Mind-wandering is more common than probably assumed. It consumes almost half of our waking hours (Killingsworth & Gilbert, 2010) and happens during nearly every daytime activity. Nevertheless, mind-wandering is different from nocturnal REM sleep, though the formation of associative networks during dreaming can lead to similar associative processes (cf. Smallwood et al., 2003).

Regarding the fact that half a day is spent in a stimulus-free state of mind, a key question is: does mind-wandering increase the frequency of creative solutions? Research on this question suggests that creative processes have long involved mind-wandering (Baird et al., 2012), specially for solving problems that have been previously encountered. It seems to even be the case that focused deliberation on problems can undermine creativity. However, distractions can enhance creativity, even while being concentrated (Dijksterhuis & Meurs, 2006). A precondition for this is a previously provided problem to solve as well as previous knowledge. The likeliness of a successful disengaging seems to rise. Such incubation intervals are even more effective and successful when supplementary external and simple tasks, not related to the primary task, are given during the breaks (cf. Mason et al., 2007; Sio & Ormerod, 2009; Smallwood et al., 2009). High levels of mind-wandering can then be measured (Baird et al., 2012), far more than during an additional demanding task or no task at all.

3.3 Creativity needs networks in the brain

Measuring concentration with imaging radiology techniques like fMRI, MEG or even EEG, activity in the lateral prefrontal cortex is displayed. This is also relevant when participants carry out language-related tasks such as translation, solving grammar problems or even mathematical actions like mental arithmetic.

That the human brain is active during phases of concentration is no surprise. However, what is interesting is that there are certain neuronal networks in charge of these processes. They all belong to the overall category of resting state networks, as they have all been measured and

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therefore discovered during a resting state of the human body (Hasenkamp, 2014; Peters, 2011; Petersen & Sporns, 2015), but also to the subcategory of Attention Mode Networks (AMN), as they are activated through instances of concentration on demanding tasks (Figure 2).

These AMN, consequently, process external information and are triggered during task-focused activities that demand full attention, such as speaking to somebody else or writing a text, bestowing them with outward cognition. Active brain regions that belong to these kinds of networks are in general parts of the insular cortex, dorsal-lateral parts of the cingulate cortex, dorsal-lateral parts of the prefrontal cortex, as well as dorsal-lateral parts of the parietal lobe (Seeley et al., 2007; Hasenkamp, 2014).

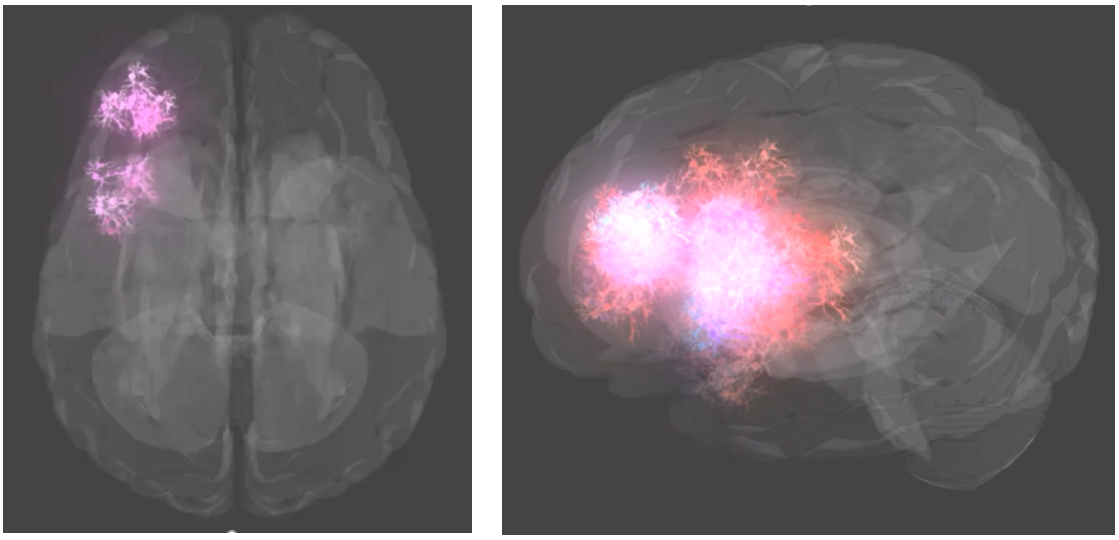

Figure 2. Activation of left lateral prefrontal cortex (LEAR Lab, 2019)

The question is now, what happens in the cortex, if there is no concentration at all. Results are not really new: even when actually 'resting', the human brain is not inactive. On the contrary: it seems that during states, such as mind-wandering and sleep, the brain is even busier. The best way to measure such behavioural states is by letting participants close their eyes or passively observe neutral stimuli, like optical crosses on a wall, and being advised to try not to think of anything special. Therefore, the mind is able to wander, and the results are fluctuations in neural activity, that can be seen in the EEG or fMRI samples. Close inspection has revealed that these are not entirely random. Instead, various regions of the brain show very similar fluctuation patterns and, hence, belong to another type of neuronal network – the Default Mode Network (DMN). It is active when

people are not task-focused during non-demanding tasks (e.g. listening to music, doodling or going for a walk). Research suggests that the DMN is active during 50% of all waking hours.

It was Raichle et al. (2001) who first described this network within the brain. Interestingly, the DMN is surprisingly cognitive, but imperceptible. The brain areas involved have the following in common and facilitate a 'default' functional state within the brain:

- they need a lot of energy due to a high resting metabolism;
- they deactivate when an external task is executed – specifically, they exhibit decreased activation associated with many goal-oriented or attention-demanding tasks;
- they are counter-correlated with active networks;
- they provide a high functional and anatomical connectivity among themselves;
- they are highly spontaneously, automatically and very quickly coherent when resting; and
- they include inward cognition.

That last aspect might seem astonishing but is due to the fact that the medial prefrontal cortex is measurably involved. This brain region has been implicated in planning complex cognitive behaviour, personality expression, decision making, and moderating social behaviour. This circumstance raises the network to a higher level and points out why it must be taken seriously as a powerful mental tool, also for acquiring languages (Figure 3).

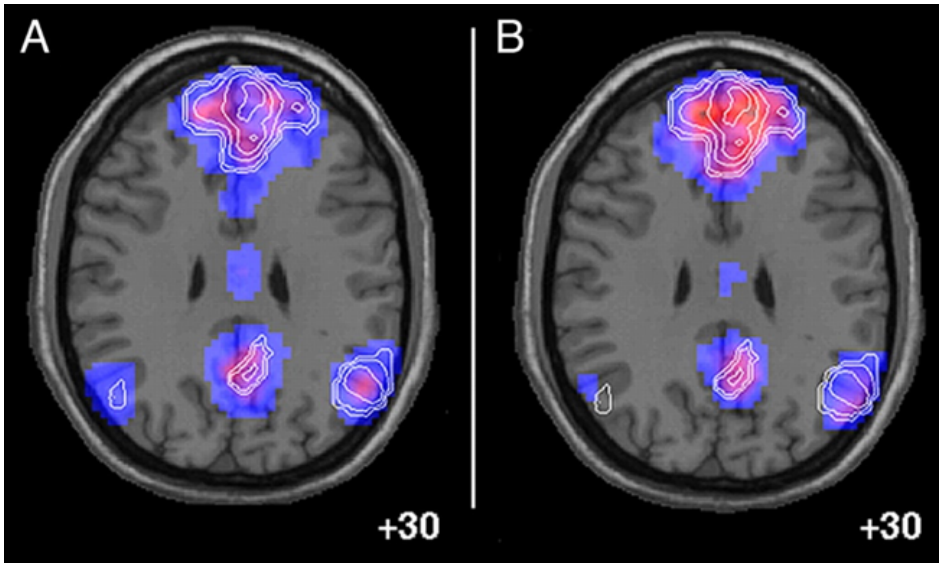

Figure 3. The Default Mode Network (Harrison et al., 2008)

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In addition, there are several other brain regions integrated into this neuronal network, such as the posterior cingulum, situated in the medial aspect of the cerebral cortex. It is a central structure of learning, and more specifically of learning to correct mistakes, and is also involved in the appraisal of pain and reinforcement of behaviour. The precuneus, which is involved in visuospatial processing, episodic memory, self-reflections, and other aspects of consciousness, makes up another important part of the network and can be found in the superior parietal lobe. Another part of the DMN is located in the inferior parietal lobe. This portion of the human brain is associated with navigation, spatial sense, as well as the sense of touch. Lastly, the medial temporal lobe forms an additional relevant component. It is not only in charge of processing sensory input into derived meanings for the appropriate retention of visual memories, but also of emotional association and most importantly language comprehension (Figure 4).

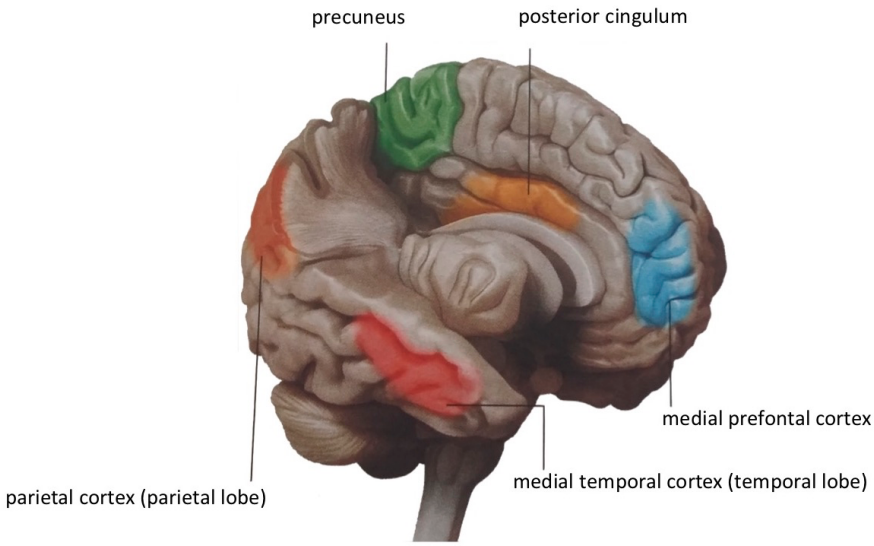

Figure 4. Components of the Default Mode Network (adapted and adjusted from Ricard et al., 2014)

All parts together form the picture of a highly complex entity not only situated on the surface of the brain as well as in younger parts of it, but also touching older parts deep within, e.g. the limbic system.

3.4 Far from being dysfunctional

Various regions of the DMN may be responsible for language acquisition related processes such as introspective or self-referential thought, monitoring of the external environment, e.g. a conversational

context, emotional processing (Broyd et al., 2009), spontaneous cognition, and predicting possible actions (Raichle & Snyder, 2007), e.g. when listening.

Much closer to language acquisition are:

- self-correcting and self-reflecting, e.g. during conversation;
- unconscious planning of speech action, e.g. in oral communication;
- expressing personality, e.g. through a certain choice of words and expressions;
- memorising, e.g. of new words and chunks;
- decision making, e.g. on how to say what to whom;
- reflecting, e.g. one's own speech habits; and
- language comprehension, e.g. in written and oral conversations (cf. Kuhnert et al., 2013).

All these competences together – and it must be mentioned at this point that the DMN activates all its areas at the same time – provide a powerful, variable and flexible if not highly creative though mostly unconscious connectome.

3.5 The DMN links to implicit learning

A clear link between DMN and implicit learning provides convincing proof of creativity in general and in linguistic performance. Almost all DMN areas of the brain overlap with those of the implicit use of the brain (Figure 5).

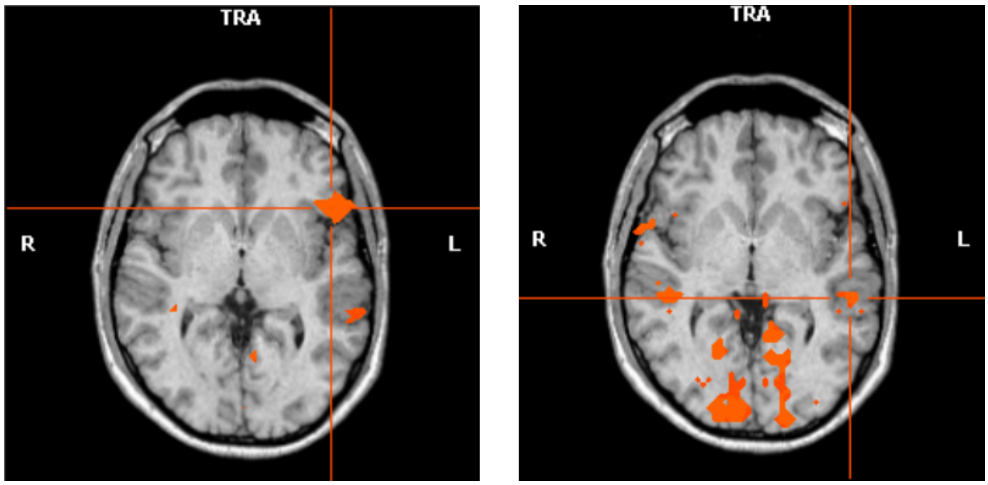

Figure 5. Explicit and implicit language learning (Kuhnert et al., 2013)

The left figure depicts a brain scan of an explicit language learner. The speech-related areas, which have been activated, are merely in the left hemisphere. To be more precise, they are found in

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the Broca area, responsible for processing language information. In contrast, the right figure illustrates an implicit form of language learning. As can be seen in Figure 5, in this case both hemispheres as well as a greater number of brain regions are triggered. Hence, implicit learning seems to be more efficient and in regard to language learning even more creative. This is true for every first language, which has been naturally acquired.

In order to make clear how deeply this distinction between explicit and implicit learning is linked to the distinction between AMN and DMN, the key features of both neuronal networks are shown in Table 1 with regard to language acquisition:

Table 1

Two main neuronal networks of the human brain related to language acquisition

ATTENTION MODE NETWORKS	DEFAULT MODE NETWORKS
triggers stimulus-dependent thoughts	triggers stimulus-independent thoughts
formal	informal
controlled	uncontrolled
voluntary	involuntary
works explicitly	works implicitly
explanation needed	no explanation needed
remembered	not registered
declarative	procedural
facilitates outward cognition	facilitates inward cognition
conscious	unconscious
attentive	pre-attentive
activated by demanding tasks	activated by non-demanding tasks
deliberate	habitual
perceptual	pre-perceptual

4. ACTIVATING THE DMN

4.1 The importance of timing

As therapists, teachers, and parents who discuss the benefits of 'down time' well know, as does anyone who has had a creative insight in the shower, rest is indeed not idleness, nor is it a

wasted opportunity for productivity. Rather, constructive internal reflection is potentially critical for learning from one's past experiences and appreciating their value for future choices and for understanding and managing ourselves in the social world.

But what steps can we actually take to use this 'down time', or more specifically the DMN, to our advantage? The mind wanders so often anyway, it doesn't need to be encouraged to do so. In order to make mind-wandering beneficial for one's search for a good idea or a solution to a problem, the right technique is necessary.

Generating ideas during a non-optimal time of day can be very rewarding. Therefore, activities must be planned ahead. If performances are much better during morning hours, one should consider thinking about creative solutions in the evening. On the contrary, one should meditate and brainstorm ideas during the first cup of coffee if evening periods tend to be normal working hours. This might sound counterproductive, for people are used to thinking that the brain works far better during optimal times when it seems to be most awake and alert. Nonetheless, this is not always the case. Analytical thinking may be superior during optimal times, but creativity is definitely higher during seemingly non-optimal times. This includes showering, jogging, and any motoric action, which is implicitly carried out.

4.2 The importance of location

Creativity does not exist in only one place. Not in one's office, one's work station, or in one's café. Creative spaces can be made by the creative people themselves. According to research interpretations, creativity needs open spaces and no narrow frameworks. This explicitly supports the DMN brain organisation, spreading over both neural hemispheres. Combined with the finding that seemingly non-optimal times can foster creativity, breaks and pauses, even brief, may be ideal places. Similarly, intersections are supportive, in which two or more unexpected, contradicting or complementary things meet surprisingly, e.g. good and bad, new and old. Also, bits and pieces brought together in new contexts can be beneficial. A last example of good 'places' are questions leading to curiosity and thus creative solutions.

4.3 The importance of technique

The healthiest way to increase mind-wandering is through mindfulness meditation. In open-monitoring meditation, while becoming aware of one's own thoughts and feelings, the meditator turns into a scientific observer of himself. Firstly, one focuses on opening one's breath, then opening the mind to allow any thoughts of sensations to occur. The aim is to allow thoughts and impressions to pass through one's mind without analysing, judgment or distractions from the inner voice. Emotional and creative responses

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are strongly fostered in such a state of mind. Another possibly easier way of activating one's DMN is by carrying out familiar and, therefore, automatic behaviour, giving the mind the opportunity to wander freely, while maintaining just enough attention to engage in those kinds of non-demanding tasks (Buckner et al., 2008; Medea et al., 2018).

4.4 The importance of balance

However, it is important to acknowledge that all resting state networks are relevant to boost your creativity. This is due to the fact that these networks are mutually dependent and the quality of each network hinges on one another (Immordino-Yang, 2016; Immordino-Yang et al., 2012). It is, of course, not always wise to interrupt a task-focused activity, simply to let the mind wander and expect tremendous creative benefits. This will most likely only lead to frustration as the task will take much longer to accomplish. On the contrary, it is much more recommendable to apply certain mind-wandering techniques as soon as you notice that plain focus is no longer able to help you overcome the mental block ahead of you.

5. DIDACTIC IMPLEMENTATION REGARDING FOREIGN LANGUAGE ACQUISITION

An essential goal of all foreign language didactics must be to make use of the DMN regarding foreign language acquisition. However, one must always treat neuroscientific findings like these with caution. They cannot simply be generalised and should not lead to hasty and erroneous conclusions. Having said this, the following four fields of action, nonetheless, can be identified as appropriate forms of didactic implementations.

Narrative comprehension. Narrative comprehension, as e.g. in storytelling, involves inferring cumulative meaning, not only the understanding of single words or chunks. Such an identification of meaning is situated in the DMN. These results demonstrate that neuro-semantic encoding of narratives happens at levels higher than individual semantic units. This encoding is systematic across both individuals and languages. So, story-telling, especially in a darker surrounding like near camp fires, with the absence of too much sensory impression, fosters language creativity through listening comprehension (cf. Dehghani et al., 2017).

Investigating influences. Investigating the influence of sad and happy music on mind-wandering and its underlying neuronal mechanisms, researchers found that sad music, compared with happy music, is associated with stronger mind-wandering. Findings demonstrate that, when listening to sad vs. happy music, people withdraw their attention inwards and engage in spontaneous, self-referential cognitive processes. These findings call for a systematic investigation of the relation between music and thought, having

broad implications for the use of music as text carriers in (language) education and clinical settings (cf. Taruffi et al., 2017).

Mental exploration. The DMN is also engaged in remembering the past and envisioning the future. Research shows that the functional connectivity of the DMN is related to the quality of remembering the past and rather marginally to future imagination.

In particular, picturing the future plays an additional role regarding one's motivation, e.g. for communicating. Mental explorations like these, and hence the DMN, help to anticipate upcoming events, prepare for communicative situations like dialogues or monologues in any language and to evaluate them beforehand (cf. Buckner et al., 2008; Medea et al., 2018; Ostby et al., 2012).

The 'social brain'. Social cognition, particularly higher-order tasks such as attributing mental states to others, has been suggested to activate a network partly overlapping with the DMN. This is called the 'social brain'. Both networks therefore seem to foster empathy, the experience of understanding another person's thoughts, feelings, and condition from his or her point of view – an indispensable precondition especially for oral communication in any social context (cf. Mars et al., 2012).

6. CONCLUSION

It is during these times of daydreaming, of recalling memories, of envisioning the future, of monitoring the environment, of thinking about the intentions of others, and otherwise, when thinking seems to be without an explicit goal, but all sensory input like language material, especially if relevant, is memorised, processed and prepared for availability whenever necessary. Though the concept of the involved network, the DMN, is not without controversy in the scientific community, it can be said that if looked upon as a resting state or an active one, the DMN and its functional areas definitely foster implicit language learning. Implicitly acquired language can be used implicitly – and therefore almost automatically creatively and fluently.

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