NEURODIDACTICS – A NEW SCIENTIFIC TREND IN MUSIC EDUCATION?

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In recent times neurosciences have become extremely attractive to all kinds of people: researchers, psychologists, politicians, musicians, music educators, and teachers. What has happened that this new branch could develop so quickly?

First, in neuroscience a sophisticated technology provides us with new brain imaging techniques (EEG, MEG, Pet Scan, fMRI) that give us access to observing the active brain.

Second, new research projects have demonstrated fascinating insight into the processing brain which have produced a new understanding of the procedures engaged in learning and understanding.

Third and finally, teachers have discovered the brain as sort of hard-ware which has to be wired appropriately, and they realized that music teaching needs to be based on a solid foundation of the mental state instead of focusing on a mere hope that music do something good to the brain (will make our children smarter)!

Within this triangle of arguments – accessible technologies, recent research findings, and educational interest – new aspects of neurosciences have been introduced into music education.

In my paper, I will (1) start with a presentation of topical research findings which relate cognitive and brain development. This functions as an entry point into (2) the demonstration of a functional correlation between music and the brain. Based on this, I will (3) explain what is meant by "neurodidactics", and then (4) proceed to a discussion of the purpose of this new dimension with respect to teaching and learning music.

I Cognitive and brain development

Neurobiologists see the brain as an active system which is genetically determined to react to incoming stimuli to discover the environment and to organize a structure for identifying and recognizing same and different types of patterns. For this, the brain develops mental representations of the perceived world around. Therefore, the brain development relies on an active interplay with a stimulating environment. This causes the foundation for what we call "developmental aptitude" (Gordon 1990). For, the brain shows a peculiar behavior; it diminishes connections which are rarely used, whereas it strengthens those connections which are frequently and repeatedly activated. In early years the brain develops a huge amount of synaptic connections to be ready for the reception and the processing of all kinds of sensational input. The environmental selection of neuronal stimulation determines the number and type of responding (firing) neurons. From the very beginning of life (if not even earlier) the brain looks for interesting new stimulation. It always gathers information from all sensational input. Thereby, it continuously looks for similar or different patterns and tries to integrate new stimuli into already existing patterns; it steadily compares sensational input with what is already stored in memory. In processing, the brain simply organizes incoming information statistically by observing and recognizing which stimuli appear more often in a series than others. Therefore, one can say that the developing brain mirrors the way of its interactions with the environment. How much information and how fast it can be processed depends on the cognitive potential (g-factor) which is genetically determined. But within a given potential to learn, the mental architecture can be developed and will be elaborated by the way it is stimulated and used. Therefore, one can conclude that the functioning of the brain is use-dependent. The more often a cell ensemble is activated and the more frequently this activation has been repeated, the more strongly synaptic connections will develop.

What I have called *environmental* interactions can also be called *social* interaction, because these interactive processes only appear in a social context. Therefore, Gerald Hüther (2000) has described the brain as a social organ rather than a cognitive processor. But probably there is no big difference between both aspects because the cognitive aptitude (within the mental potential) results from social activities and emotional social connections. Anyhow, during the brain developing phase parents, care givers, siblings, and peers are the most important, powerful, and influential agents for the developing child. Most of what children learn – namely the really essential faculties such as upright position, walking, body coordination, speaking, concept building, logic thinking etc. – is not taught formally, but arises from informal unstructured guidance by observation, imitation, and exploration.

In this process, the emotional response is crucial. Whenever a perceived set of sensorial data can be integrated because a similar set is already established, the limbic system disseminates dopamin which causes contention and happiness. By this, the brain seeks for a repetition of this state so that finally the efficient activation will be strengthened and stored in long term memory (Spitzer 2002). That means that only emotionally reinforced meaningful information provides a chance for sustained learning. Learning itself is an auto-fostering process which is based on a particular bio-feedback. This circle of self-regulated learning can be disturbed or reinforced by teaching strategies; in any case it should be recognized and respected.

II Music (Learning) and the brain

Music learning affects the brain – not in that trivial sense that music makes us smarter, but – as neuroscience has shown by brain imaging technologies – music making causes structural and functional differences in the brain such as gray matter volume differences in motor and auditory brain regions (Gaser 2003) or stronger brain asymmetries in musicians (Schlaug 2003; Gaab 2003). These differences which have been documented by several fMRI studies can be referred to learning, or the other way around: learning can be described in terms of functional and structural brain changes.

This is an important step towards a better understanding of learning and a more objective documentation of the processes involved in learning. In view of this, investigations on neural responses to learning tasks are crucial. Animal experiments have shown that mice who grew up in an enriched environment (with a running wheel and several toys) developed significantly more hippocampal neurons than mice in an empty cage (Kemperman et al. 1997). In an experiment with gerbils (gerbillinae) it was found that correctly mastered tasks increased the level of dopamin by which these animals sort of recompensed their successful learning (Friedrich & Preiss 2002, 68). Furthermore, it could be shown that deprived little bush rats (octogon degus) could not stop the overproduction of synapses during their first weeks of life. If the balance of stimulating and inhibiting connections is damaged it causes a disturbed learning behavior (Braun & Bock 2003).

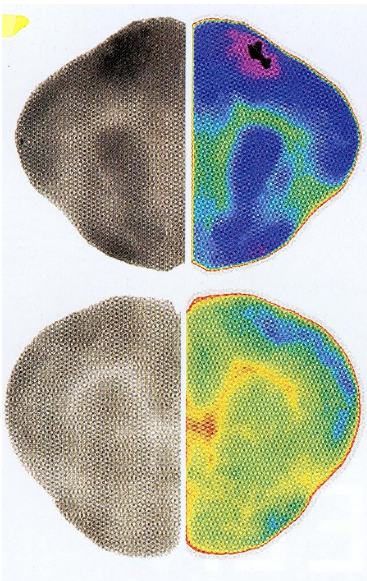

Fig. 1: Metabolism changes and brain activation differences in bush rats (degus): deprived rat (above) versus normal development (below).

What is exhibited by animal experiments might be true for human learning as well. The brain develops different sequential stages which educators should know so that they can correspond to the developmental state of the brain. Since we know that a dopamin signal causes higher activation of the ventral striatum which affects the frontal lobe and, therefore, produces a gating effect for new information, we can assume that information processing and knowledge acquisition will be more successful in a context that provides positive feelings and successful experiences. To count mistakes and insist on how bad a student behaves cannot be as successful as a positive feedback and the experience that something has been achieved. This can be initiated by presenting new stimulation situations which correspond to the novelty seeking behavior of humans.

In a long-term music learning experiment (Altenmüller & Gruhn 2000) it could be demonstrated that brain activation patterns change depending on different learning modes and teaching strategies. Those pupils who could develop a genuine musical representation by procedural strategies were more successful in the listening task than those who were verbally trained. The more successful students revealed a much more distributed and economically lower activation. Furthermore, students who showed the distributed activation pattern, did not only learn the particular task of the test, rather they developed categories that enabled them to continue in a process of self directed learning. This was finally reflected by an increase of their achievement in a test one year later without any specific training.

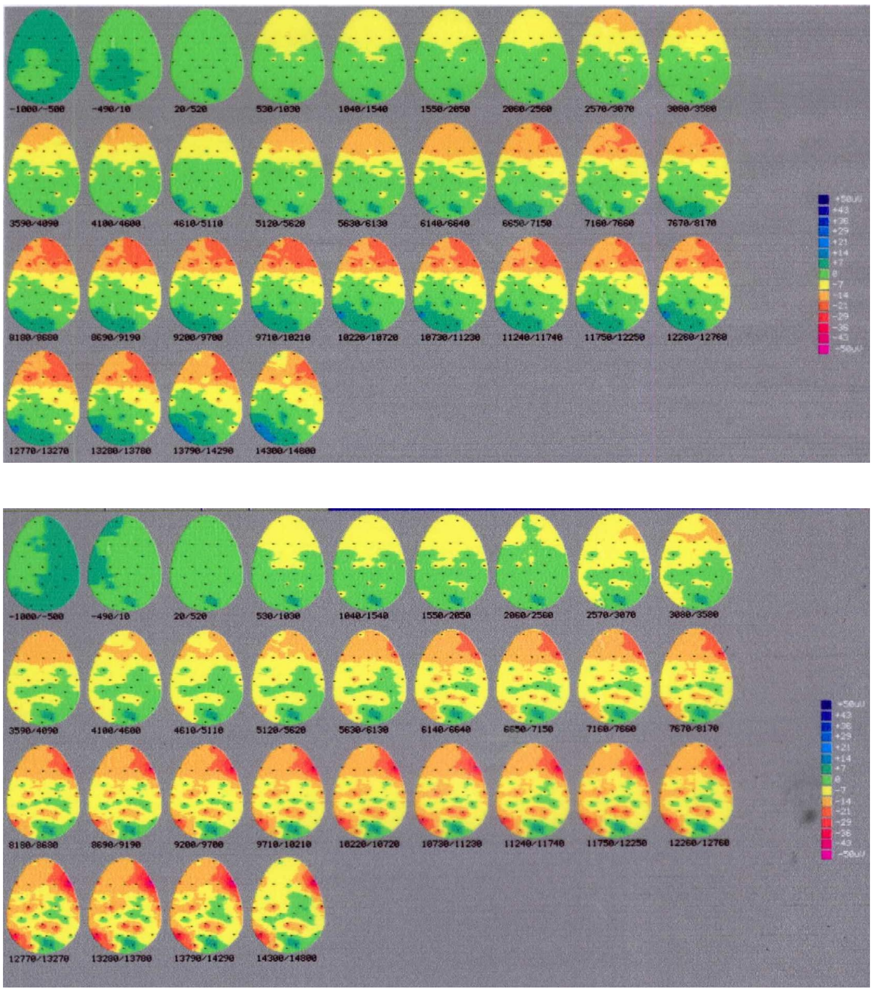

Fig. 2: Cortical activation patterns in students with a declarative (above) and procedural (below) learning strategies.

Finally, comparing measurements of mental speed in musically trained young children and average peers without music exhibits a significant mental age advantage in musically trained children who are up to two years ahead in tasks of mental speed.

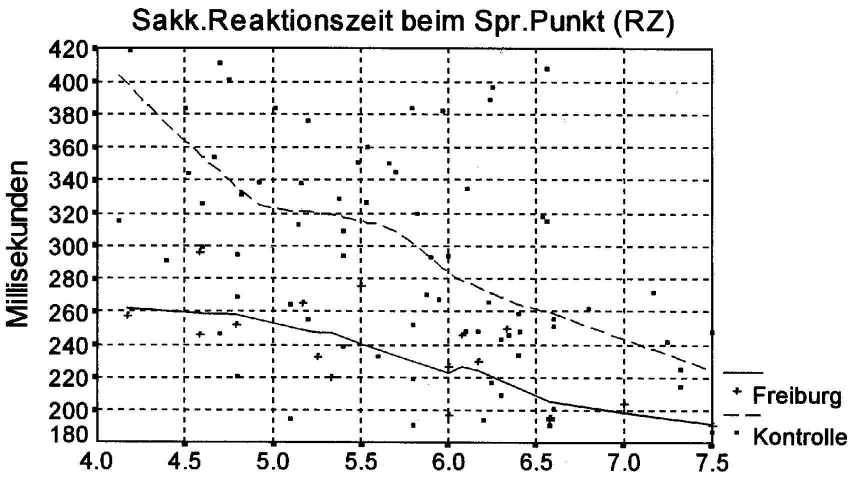

Fig. 3: Advantage in mental age for musicians compared with non-musicians

These and other findings indicate a strong interaction between brain development and learning which can be considered to become an important aspect for teaching and learning in general, and for music education in particular. We should observe and take into consideration the validity of this interaction to make music teaching and learning more powerful and successful.

III Neurodidactics, or: what makes a good learning environment?

The term "neurodidactics" that describes a new discipline related to neurosciences on the one hand and education on the other, goes back to the German educational scientist Gerhard Preiss (1998). By this, he provides a new foundation of viewing the learning processes in accordance with the state of brain development. If we know about electro-chemical and hormonal processes that enhance synaptic strength and facilitate long-term representation that can be re-activated at any time, methods and teaching strategies (= didactics) as well as the organization of environmental sets for teaching and learning, curriculum development and school policies can be related to the developmental state of the brain and its neurobiological conditions. Here, we must question: what makes a good learning environment appropriate to the conditions of the learning brain.

It is hardly possible to present distinct recipes to follow up with to achieve successful music teaching. However, there are general principles to comply with. For example, if the brain does not need rules and doctrines, but powerful samples and models to act with, then it does not make sense to explain an issue or present a content verbally.

Based on neurobiological knowledge upon learning, we can conclude with some recommendations:

1. Mental representations need time to develop. Therefore, we must concede enough time for students to gather experiences.

2. The brain reflects all practical embodied experiences. Therefore, students need many options to prime the brain for learning and to install the most efficient neural networks.

3. Not the content, but the context, i.e. the relation between the elements of a content, creates meaning.

4. The learning of meaning must be closely related to the sensitive phases when the brain is best prepared to process and store new information.

5. Learning is best accomplished if positive feelings can be attributed. The best chance for a new content to be preserved in memory is that we arrange a learning situation in which learning can produce pleasure. Motivation is nothing implemented artificially into the teaching process, rather motivation is a consequence of successful learning, it is kind of a self stimulation that we want more of what makes us happy. This auto-poetic systems, i.e. that we get involved into a process not for concrete benefits, but for the action itself, the goal of which is given by itself, is the prerequisite for what Csikszentmihalyi (1975) has called "flow".

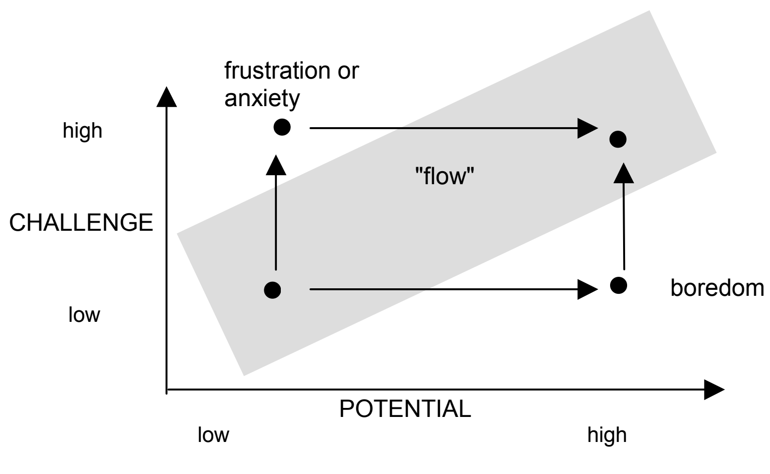

Fig. 4: The balance of boredom and anxiety in the flow experience (according to Csikszentmihalyi 1975).

6. Teaching music should always focus on procedures that can help the students to develop mental representations of musical, not theoretical or verbal issues. Mental representation is the crucial issue in "neurodidactics". However, mental representations can only be developed by the students themselves, but as educators we are responsible to arrange stimulating learning settings and to present new elements in a partly known and

attractive context which is meaningful in itself and catches students' interest. Therefore, the structure of teaching must be adopted to the biological and physiological conditions of the developing brain.

IV Music education and neurosciences: advantages and difficulties to relate brain research to music education

What can brain research tell us about learning? Can methods be deduced from brain research? It seems clear that although we could possibly know what every neuron does, we could not predict the degree of learning, and even less we could decide about what should be learnt and taught. "All the wiring in the brain, known in detail down to the last synapse, can never account for [teaching] values." (Gardner 1999, 79). But teachers could become aware of *when* and *how* a content should be presented so that it can pass an open window to get into an already established brain structure.

Therefore, brain research is not a magic mystery that accounts for the teaching and learning, but - as in neurodidactics - it can base our knowledge on more solid and objective facts and look for the effect in an actual teaching and learning situation. By this, it could enable us to adopt the teaching to the mental state of a child, instead of trying to adopt the child to the structure of a given curriculum.

Teaching is a social product and a social process all at once. The teacher is his/her strongest curriculum (H.v.Hentig) – but (s)he must know what his/her doing possibly causes in he brain. Hence: the way of learning effects the brain structure. Its neural setting determines to what degree one can learn – as we have mentioned earlier: since learning is reflected by neural changes. And achievement depends on the structural and functional differences. Therefore, "neurodidactics" articulate more than a vague (diffuse) hope for cognitive transfer effects, it sets the frame for many educational decisions (covered by the term "didactics") which is defined and limited by the neural conditions of the brain.

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