THE MULTI-CODE LANGUAGE OF THE MIND. A SURVEY ON TEACHERS' EDUCATIONAL PRACTICES

IL LINGUAGGIO MULTI-CODICO DELLA MENTE. UN'INDAGINE SULLE PRASSI DIDATTICHE DEGLI INSEGNANTI

Martina Albanese
University of Palermo
martina.albanese@unipa.it

Abstract

In planning the educational offer, the educator/teacher must consider the emerging neuroscientific evidence concerning the multi-codic language of the mind and the peculiarity of each evolutionary trajectory. After framing the different multi-codic influences that characterize the formation of brain configurations (two examples are reported: one linked to the cognitive sphere and one linked to motor skills and corporeality), the consequent peculiarity of each student or person in training is underlined.
In the second part of the paper, a survey conducted with 440 teachers of the first and second cycle school during the second semester of the A.S. 2020/2021. The survey was conducted through the administration of the "Questionnaire for the detection of neuro-didactic practices" and aims to measure the level of knowledge and use of the neuro-educational and neuro-didactic principles in the teaching practice of teachers. With respect to the five areas investigated (transversal, cognitive, socio-affective, linguistic and praxic-motor), the most significant results are discussed regarding the programming of activities and teaching material, taking into consideration some neuro-educational principles concerning the multi-codic functioning of the brain.

Nel programmare l'offerta educativa è necessario che l'educatore/insegnante tenga conto delle emergenti evidenze neuroscientifiche che riguardano il linguaggio multi-codico della mente e la peculiarità di ciascuna traiettoria evolutiva. Dopo aver inquadrato le diverse influenze multi-codiche che caratterizzano la formazione delle configurazioni cerebrali (si riportano due esempi: uno legato all'ambito cognitivo e uno legato alla motricità e alla corporeità), si sottolinea la conseguente peculiarità di ciascuno studente o persona in formazione.
Nella seconda parte dell'elaborato si espone un'indagine condotta con 440 insegnanti della scuola del primo e del secondo ciclo durante il secondo semestre dell'A.S. 2020/2021. L'indagine è stata condotta tramite la somministrazione del "Questionario per la rilevazione delle prassi neuro-didattiche" e ha lo scopo di misurare il livello di conoscenza e di utilizzo dei principi neuro-educativi e neuro-didattici nella prassi didattica degli insegnanti. Rispetto le cinque aree indagate (trasversale, cognitiva, socioaffettiva, linguistica e prassico-motoria) vengono discussi i risultati maggiormente significativi che riguardano la programmazione delle attività e del materiale didattico tenendo in considerazione alcuni principi neuro-educativi riguardanti il funzionamento multi-codico del cervello.

Keywords

neuroeducazione; cervello; prassi didattiche; multi-codicità; unicità.
neuroeducation; brain; educational practice; multi-coding; uniqueness.

1. A complex multi-coded interaction underlying brain functioning

"There is no separation of brain, mind, body, feelings, social contacts, or their respective environments" (Jensen, 2008, p. 412).

The idea that brain functioning depends on multi-codic modalities that make the body, feelings, social interactions and living environments an indispensable unit of elements is increasingly consolidated.

Today, thanks to imaging techniques, it has been possible to demonstrate that in any type of task the network of connections that is generated is not localized according to a static and preordained division of the brain, rather the neuronal networks come into action simultaneously in several points of the cerebral cortex, even activating parts that are very distant from each other (Sablonnière, 2018, p. 67).

Thus, it is possible to observe this particular property of dynamic interdependence of the brain with respect to tasks of a cognitive nature, of a socio-emotional nature, of a physical-motor nature, etc.

The neurobiological basis of learning consists in these complex neuronal communications that are based on the action potential and release of neurotransmitters, some of which have enormous repercussions in the classroom. "For example, high dopamine levels cause the pupil to motivate himself by playing; high levels of serotonin that laughs; low levels of norepinephrine which distracts you; and low levels of acetylcholine that falls asleep during a boring explanation" (Guillén, 2021, p. 16).

Further examples can be provided that can do justice to this emerging neuroscientific awareness. Below, reference is made to two arguments in support of the multicode brain functioning that regulates learning: on one hand relating to cognitive nature aspects and on the other relating to motor nature aspects.

If we take into consideration the memorization process and therefore a cognitive task, it is possible to state that many neurobiologists have observed a selection action of the brain, which translates into a double procedure of "coding": the brain, in fact, at first it perceives key information and encodes it in the form of images, symbols or words; subsequently associates a meaning to the event to be retained without retaining its details (Sablonnière, 2018, p. 99). The phase of encoding a memory is followed by the "storage" phase: the retained details are sent from the hippocampus to the neuronal networks of the cortex which "stores" them. Once this is done, "consolidation" follows, for which repeated connections are required between the hippocampus and the cortex. Finally, in the "recall" phase, the hippocampus activates the various regions involved to update or enrich the event (Sablonnière, 2018, p. 100).

All this suggests that to recall the event it is necessary to retain a significant element that can be characterized by stimuli of a very different nature such as, for example, the temporal or spatial context, the people involved or the topic, images, sounds and odors, in each of the activated neuronal networks (Sablonnière, 2018, p. 105).

Invoking the senses, the environment and primary relationships has important repercussions for education and teaching, first because, even if the neurons that are generated during a learning session can be very resistant, it is based on how we use our brain whether that information is consolidated or not. Some scholars have stated in this regard: "use it or lose it" (Shorts et al., 2012). So, if on the one hand repetition[1] helps to consolidate a neuronal network, it is the integration of new neurons through experiences never attempted before that makes the differ-

1 Repetition has immediate effects on working/short-term memory, but it also has effects on long-term memory. Through neuro-imaging techniques (such as MRI and EEG), it has been seen that after a few weeks of repeated cognitive training, the brain begins to consume less oxygen while performing the same task (Sablonnière, 2018, pp. 128-129). Another study, applied to the analysis of visual-spatial abilities, carried out through the analysis of PET images, showed a decrease in glucose consumption in the long term (Haier et. Al., 1992). All this suggests that the activation of a given connection becomes more effective and cheaper over time thanks to repetition.

ence. All this suggests that in the educational-didactic process it is important, for the purpose of consolidating the neuronal connection, to provide meaningful experiences related to an environment capable of stimulating the senses, promoting interpersonal interaction capable of creating solid synaptic connections.

In this scenario, as noted by Oliverio (2018), the principle of cerebral neuroplasticity[2] must be placed at the center of neuro-pedagogy, whereby "the brain is able to modify its structure on the basis of environmental stimuli, of experience". Therefore, reducing or decreasing experiences and stimuli means influencing the cerebral modifications that determine personal specificities or that lead to anomalous modifications that mark the possible onset of pathologies (Regni, Fogassi, 2019, p. 238).

In other words, learning can generate changes in the gray matter (with reference to the hippocampus) (Sablonniére, 2018, pp. 38-39). One of the exemplary studies in this sense was conducted by Yongmin Chang (2014), a radiologist from South Korea, who using magnetic resonance imaging during various sports activities, it has shown an increase in the cortex in specific areas according to the learning of different disciplines practiced continuously for at least six months. Conversely, in the same study it was noted that the cessation of sporting or artistic activity corresponds to a decrease in volume.

This study allows the migration and deepening of another field, in addition to the cognitive one, in which many neuroscientific studies have been carried out that can make significant repercussions for education and teaching, and which confirms the harmonious holistic functioning of the brain: the motor-praxic field.

Neuroscientific studies have amply demonstrated the dynamism and integration of all components of the brain, disintegrating the idea of the motor system as peripheral and executive (Rivoltella, 2012, p. 105). It follows that the body becomes the main means through which "by creating experiences, we develop learning and produce knowledge" (Rivoltella, 2012, p. 109). Cognitive activity and body involvement are therefore interdependent.

The strong correlation between movement and cognition is supported by numerous empirical evidences, so much so that in this regard Jensen (2008, p. 415) states that "exercise is strongly correlated with increased brain mass, better cognition, mood regulation, and new cell production". This means that exercise is the source of an important neurogenesis activity (Van Praag et al., 1999; Pereira et al., 2007), which in turn improves learning and memory (Kitabatake et al., 2007).

Studies on the motor development of a child suggest to the educational sciences that the main characteristic for which a child knows and explores the world is motor skills. In fact, the child moves within a visual, tactile, and acoustic context surrounded by objects. When one of these objects strikes the child's attention, his premotor areas are activated which produce potential acts and possibly a movement towards that object that will begin to be manipulated through the joint use of eye, postural, tactile, prehensile movements (Regni & Fogassi, 2019, p. 276).

This awareness refers to the concept of "affordance" provided by Gibson (2014) for which the physical characteristics of an object suggest to the interacting subject a possibility of action; for this reason, it is "indispensable for the execution of effective gripping movements that the intrinsic visual characteristics of the object are transformed into adequate finger movements and that the finger movements themselves are divided in the correct way to obtain the configuration necessary for the movement of prehension" (Làdavas & Berti, 2009, p. 56).

Indeed, a motor act is driven by motor systems which receive information from sensory systems; physical energy is transformed into nervous information by perceptual systems (which refer to the environmental situation); finally, nerve information is transformed into physical energy which is transmitted to the skeletal muscles through motor commands (Làdavas & Berti,

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2 Plasticity is an "intrinsic property" of the CNS (Central Nervous System) which during a person's life allows the brain to adapt from a structural point of view, but also functional to environmental conditions, physiological changes, and experience (Bolognini, Vallar, 2015, p. 82).

2009, p. 53). So, when you intend to make a movement, almost the entire cerebral cortex is activated: in fact, if on the one hand the visual information excites the occipital lobe, the processed information then goes to stimulate the parietal and temporal lobe so that an object is recognized and located in a space. Finally, the information moves into the prefrontal cortex for movement planning, activating the motor cortexes for its execution.

Once again, different brain functions merge, giving rise to different synaptic configurations capable of providing adequate responses to the contexts and to the different sensory characteristics received. For this reason, "[…] teachers who stimulate all facets of their students' minds, brains, and bodies are often so successful" (Cozolino, 2013, p. 146).

2. The brain configuration of each student

In the wake of what has been said so far, one cannot fail to consider that the infinite possibilities of sensory, cognitive, environmental, and social interactions involve a specific and revolutionary awareness: the possibility of development is vast and complex.

Today, neuroscientific studies have confirmed and affirmed the pedagogical postulate relating to the uniqueness of each person. In fact, brain functioning suggests that the variability of mental and cognitive abilities does not depend so much on the number of genes, but on the ability of neurons to connect with each other (Sablonniére, 2018, p. 21) and this happens according to various times, influences and modalities. and many.

In support of this, Sophia Mueller in 2013 through the analysis of images derived from the fMRI of 579 people showed that certain brain regions, in particular the frontal lobe and parietal lobe, frontal cortex, and temporal cortex, show marked individual differences in terms of density of connections. These regions, in fact, are responsible for the formation of character, memory, self-control, intelligence (Mueller *et al*, 2013).

Sablonnière (2018, p. 33) also explains that another element that determines the inter-individual variability is to be referred to the speed in the transmission of messages in terms of nerve impulses between neurons. In general, it has been shown that in a specific task the activation of the networks is rapid (less than 50 milliseconds), but the activation of the same depends on a pluricodicity such that it is not possible to determine exactly how many, which ones and at what speed they will activate such networks in a comparison between individuals.

All this suggests that within educational contexts one cannot fail to keep in mind the intrinsic property of the brain system relating to inter-individual variety. Therefore, students are not only characterized by synaptic connections, but also possess personal characteristics, learning styles, behavioral and functional predispositions such that traditional teaching is now obsolete and totally ineffective. On the contrary, other training proposals, such as multisensory teaching or embodied cognition, today provide excellent ideas so that what has been said can be enhanced and promoted.

The approaches that assume the assumption of inter-individual variability are increasingly accredited. For this reason, the first attempts to transpose neuroscience into neuro-didactics that reflected a rigid decomposition of the brain topology have been superseded by more dynamic models[3].

In other words, "our intelligence is the result of a large number of neurons and connections as well as the sophisticated organization of neuronal networks, especially those located in the frontal cortex" (Sablonnière, 2018, p. 82).

This takes on greater rigor if we consider the high number of neurons present in an adult individual (about 90 billion) and the density of possible connections equal to 5000 connections

3 For example, the model of multiple intelligences ("Multiple intelligences") of the psychologist Howard Gardner (1992) who identified nine forms of intelligence typical of the human being that should not be understood as nine distinct intelligences, but on the contrary, complementary, and interacting. The nine intelligences are: logical-mathematical, linguistic, musical, corporeal-kinesthetic, interpersonal, spatial, intrapersonal, naturalistic, and existential.

between one neuron and the adjacent ones, which involve a possibility of about "100000 kilometers of 'cables'" (Sablonnière, 2018, p. 32).

The multiplicity of possible development paths and therefore the uniqueness of each individual evolutionary path strengthens and feeds the educational-didactic principle of personalizing learning.

Tomlinson and Murphy (2015) questioned what the pillars of differentiated education are, coming to affirm that the necessary conditions are based on: (a) the possibility of offering a positive and safe environment in which adequate challenges are proposed; (b) on providing a curriculum that is coherent, interesting and whose objectives are clear to all; (c) on deploying formative assessment; (d) on harmonizing individual and group teaching; (e) on teacher-pupil collaboration.

In learning environments set up like this, priority is given to the learning pace of each student, as each brain is unique. Guillén (2021) affirmed that creating inclusive classes is "an authentic educational and social necessity" and this is possible where the idea is accepted that there is no "normal brain", but there are different people who learn together, cooperating in an active and autonomously.

3. Survey of neuro-educational practices: a survey with teachers

During the second semester of the A.S. 2020/2021 a survey was carried out for the detection of educational and didactic practices with the teachers of the first and second cycle of 10 schools in the province of Caltanissetta.

The purpose of the tool administered, the Questionnaire for the detection of educational-didactic practices, is to measure the level of knowledge and use of the neuro-educational and neuro-didactic principles in the teaching practice of teachers, investigating five macro-areas:

1. Transversal area (item 1-29) (further divided into: general brain organization, methodological-didactic general principles, soft skills, learning environment/setting).
2. Socio-emotional-affective area (items 30-34).
3. Cognitive area (items 35-43).
4. Linguistic-communicative area (items 44-47).
5. Praxic-motor area (items 48-55).

The reference sample was asked to express the frequency according to which the proposed neuro-didactic statements occur, according to a 5-point Likert scale (from 1 "Never" to 5 "Always"). The scale, in fact, has the advantage of not working on two bipolar situations, but allows the subject to place himself at an intermediate level with respect to the opposite situations.

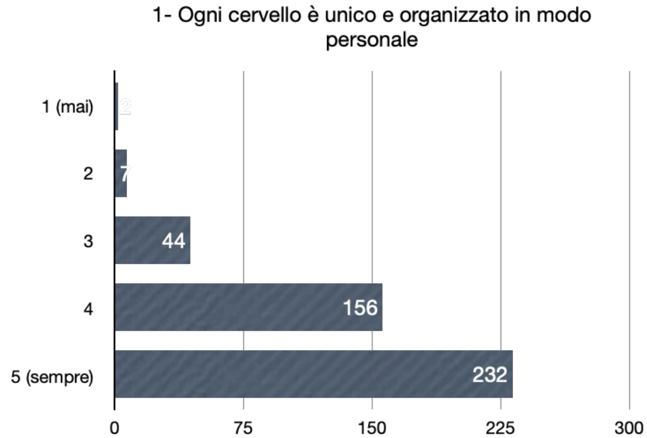
The questionnaire was administered via the Google Modules platform.

440 teachers participated, of which 93% women and 7% men. 40.6% of the respondents are primary school teachers, 33.3% are lower secondary school teachers, 21.7% are upper secondary school teachers and only 4.4% are primary school teacher.

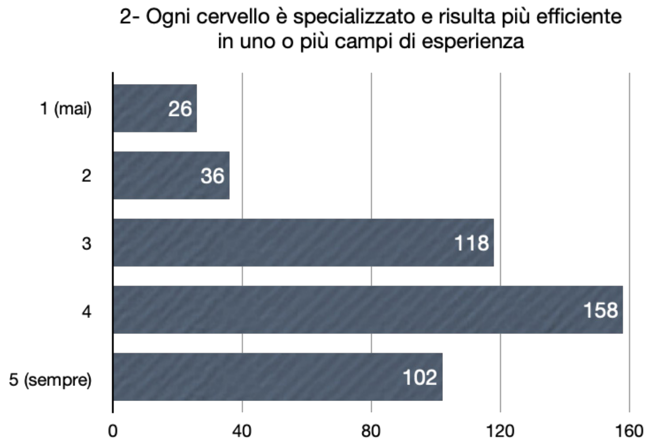
3.1. Data analysis

With respect to the five areas investigated, some more significant answers have been identified which will be discussed below and which concerned the possibility of programming the activities and teaching material taking into consideration some neuro-educational principles concerning the multi-codic functioning of the brain.

Starting from the analysis of the transversal area, it is possible to state that the teachers interviewed declared that they pay attention to the aspects relating to the organization of the brain for which it is believed that each student is unique and with peculiar characteristics (see graph 1), as well as who specializes in one or more fields of experience (see graph 2).

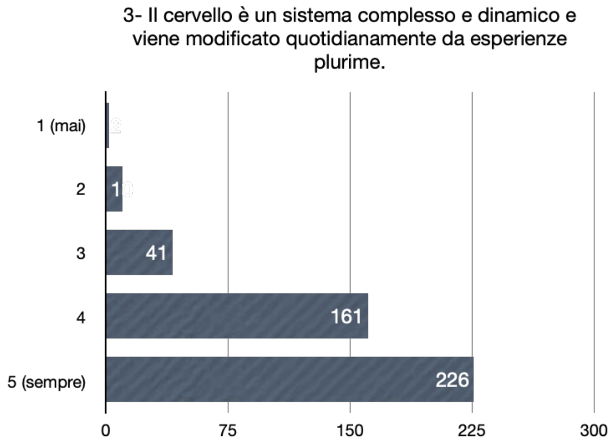


Graph 1: "Item 1 responses - each brain is unique and personally organized".



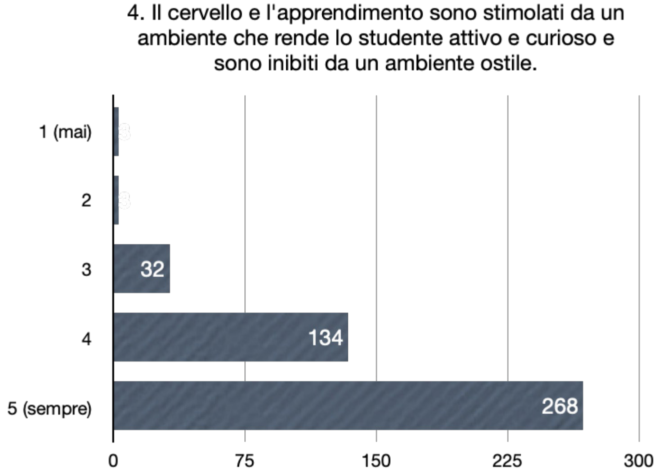
Graph 2: "Item 2 responces - each brain is specialized and is more efficient in one or more fields of experience".

Furthermore, it is believed that the brain is modified daily by experiences of multiple matrix: sensory, environmental, relational, as shown by graph. 3.

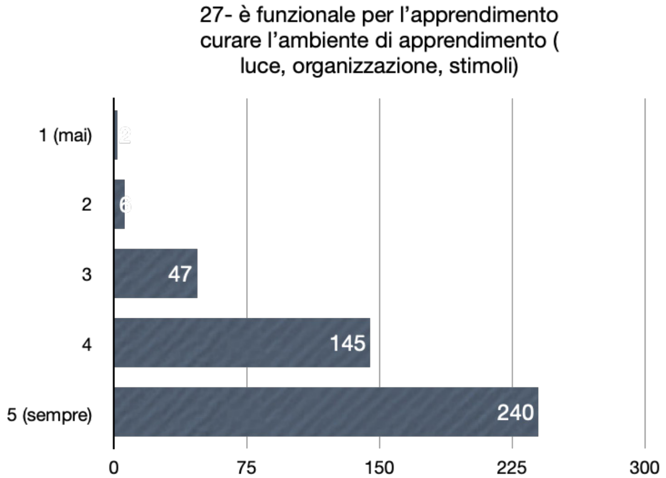


Graph 3: "Item 3 answers - the brain is a complex and dynamic system and is modified daily by multiple experience".

The position of the teachers on the importance assumed by the environment is clear. In fact, 60% of the interviewees declared that they always pay attention to the climate established in it (see graph 4); percentage confirmed (54%) also with reference to the stimuli and characteristics of the setting inserted and/or present in the learning environment (See graph. 5).

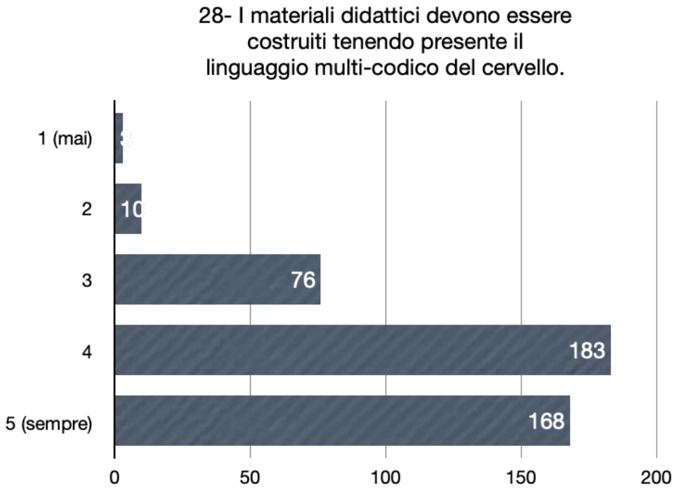


Graph 4: "Item 4 responses - the brain and learning are stimulated by an environment that makes the student active and curious and they are inhibited by a hostile environment".



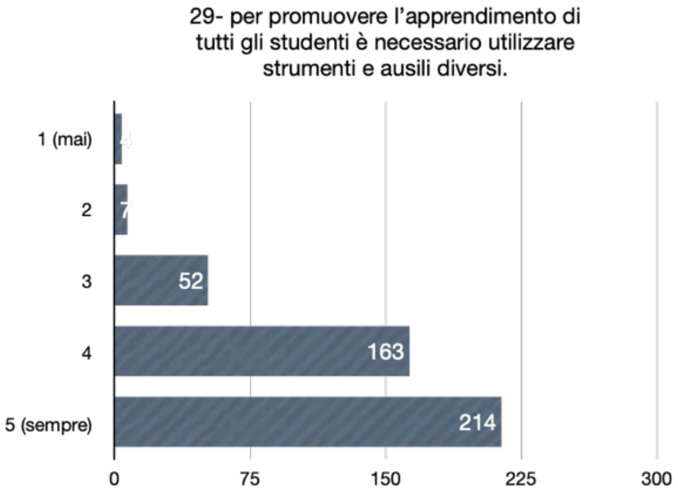
Graph 5: "Item 27 responses - it is functional for learning to take care of the setting (light, organization, stimuli)".

By proposing a specific focus on teaching materials, it is asked whether the multi-codic language of the brain is considered (see graph 6), also in this case the answers are localized in the possibility of an answer "always" (38%) and " almost always "(41%), although 17% say they do it sporadically and 3% "never" or "almost never".



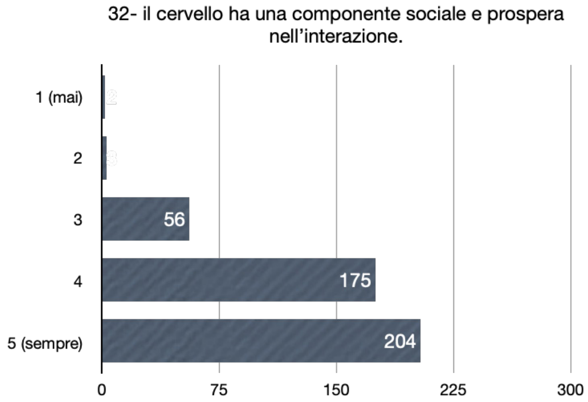
Graph 6: “Item 28 answers - didactic materials must be constructed keeping in mind the multi-codic language of the brain”.

In addition to the focus on teaching materials, teachers were asked whether they use docimological tools and aids of different nature to promote student learning (see graph 7).The teachers agree that this is done regularly, so much so that 48% say they do it “always” and 37% “almost always”.



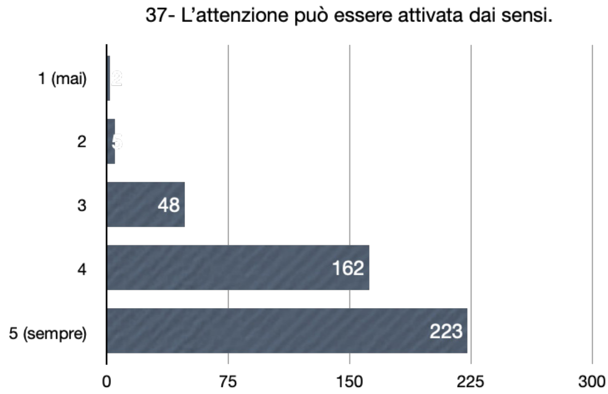
Graph 7: “Item 29 responses - to promote learning for all students it is necessary to use different tools and aids”.

As discussed, the brain is influenced by the senses, by the setting, but also and above all by the relationships with the educational figures of reference. For this reason, teachers were asked if they consider the fact that the brain has a social component, so much so that it is defined by some scholars as the “social brain” (Cozolino, 2013), and that it thrives on iterating with peers and with the carers (see graph 8). The results are comforting as 46% say they take this assumption into consideration “always”, 39% “almost always”, 12% “sometimes”.

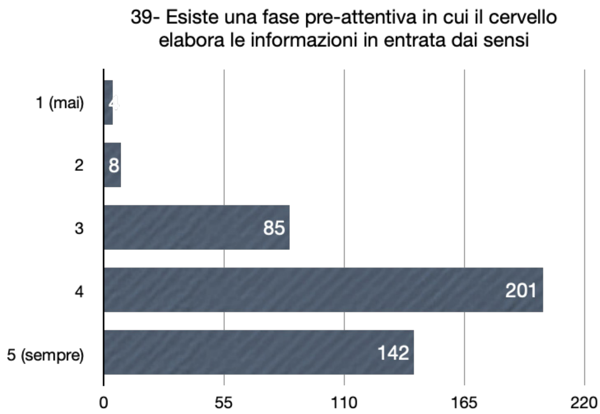


Graph 8: "Item 32 responses - the brain has a social component and thrives in interaction".

In relation to the cognitive sphere and bearing in mind the multicode component taken into consideration, teachers were asked if they consider that students' attention can be activated through the 5 senses (see graph 9) and if they know there is a pre-attentional phase which is activated by the sensory receptors (see graph 10). The trend analyzed so far is confirmed, although with respect to the awareness of the pre-attentional phase, the answers relating to a sporadic frequency with which this assumption is considered in the planning of didactic activities grow.

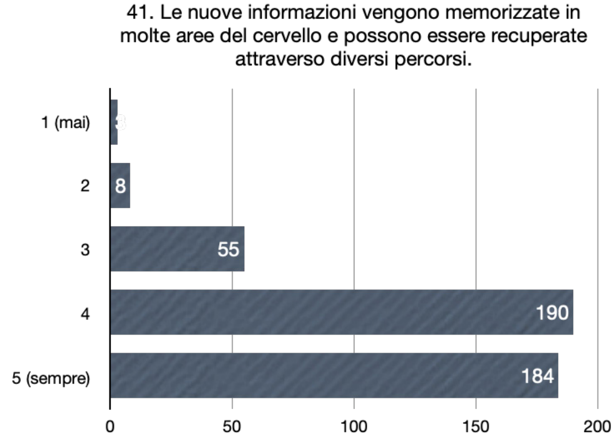


Graph 9: "Item 37 responses - attention can be activated by the senses".



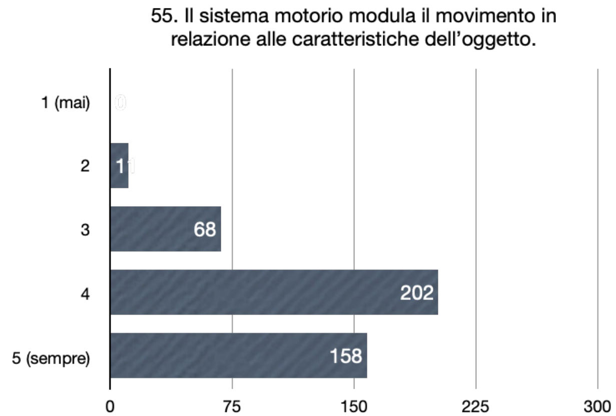
Graph 10: "Item 39 responses - there is a pre-attentional phase in which the brain processes the information incoming from the senses".

Remaining within the cognitive area, teachers were asked if they keep in mind that mnemonic processes involve different areas of the brain, therefore, they can be recovered in different ways (see graph 11). The results are leveled with respect to the possibility of answering "always" (41%) and "almost always" (43%), 12% remains on a sporadic basis.



Graph 11: "Item 41 responses - new information is stored in different areas of the brain and can be retrieved through different pathways".

Finally, a brief mention is to be made of the praxico-motor field within which the teachers were asked if they keep in mind the fact that the body movement is influenced by the characteristics of the object, recalling the concept of affordance provided by Gibbs (cf. graph 12). The data are slightly different, although most of the responses are stationed between "always" (35%) and "almost always" (45%), there is an increase in positions "sometimes" (15%) and "almost never "(2.5%).



Graph 12: "Item 55 responses - the motor system modulates movement in relation to the characteristics of the object".

In summary, it is possible to state that through the survey carried out and with reference to the non-probabilistic sample involved, it emerged that teachers have a good awareness of the multiple, dynamic, and multi-perspective functioning of the brain. The results, however, cannot be generated and would require further investigation.

In conclusion, it is possible to state that in planning the educational offer it is necessary for the educator/teacher to consider the emerging neuroscientific evidence that affirms the harmonious and holistic brain functioning in various tasks related to learning.

Bibliografia

Bolognini, N. & Vallar, G. (2015). Stimolare il cervello. *Manuale di stimolazione cerebrale non invasiva*, Bologna: Il Mulino.

Chang, Y. (2014). Reorganization and plastic changes of the human brain associated with skill learning and expertise. «*Frontiers in human neuroscience*», 8, 35.

Cozolino, L. (2013). *The Social Neuroscience of Education: Optimizing Attachment and Learning in the Classroom (The Norton Series on the Social Neuroscience of Education)*. WW Norton & Company.

Gibson, J.J. (2014). *The ecological approach to visual perception: classic edition*. Psychology Press.

Guillén, J. C. (2021). *Neuroeducazione in classe. Dalla teoria alla pratica*, Roma: Il Bruco farfalla.

Haier, R. J., Siegel, B., Tang, C., Abel, L., & Buchsbaum, M. S. (1992). Intelligence and changes in regional cerebral glucose metabolic rate following learning. *Intelligence*, 16(3-4), pp. 415-426.

Jensen, E.P. (2008). *A fresh look at brain-based education*, «Phi Delta Kappan», (LXXXIX) 6, p. 408-417.

Kitabatake, Y., Sailor, K.A, Ming, G.L. & Song, H. (2007). Adult neurogenesis and hippocampal memory function: new cells, more plasticity, new memories? «*Neurosurgery Clinics*», XVIII, 1, pp. 105-113.

Làdavas, E. & Berti, A. (2009). *Neuropsicologia*, Bologna: Il Mulino.

Mueller, S., Wang, D., Fox, M. D., Yeo, B. T., Sepulcre, J., Sabuncu, M. R., ... & Liu, H. (2013). Individual variability in functional connectivity architecture of the human brain. «*Neuron»*, 77(3), pp. 586-595.

Oliverio, A. (2018). Neuroscienze e educazione, «*Research Trends In Humanities Education & Philosophy*», *5* (2018), pp. 1-4.

Pereira, A.C., Huddleston, D.E., Brickman, A.M., Sosunov, A.A., Hen, R., McKhann, G.M. & Small, S.A. (2007). An in vivo correlate of exercise-induced neurogenesis in the adult dentate gyrus, «*Proceedings of the National Academy of Sciences*», 104, 13, pp. 5638-5643.

Regni, R., & Fogassi, L. (2019). *Maria Montessori e le neuroscienze. Cervello, mente, educazione.* Roma: Fefè Editore.

Rivoltella, P.C. (2012). *Neurodidattica. Insegnare al cervello che apprende*, Milano: Raffaello Cortina.

Sablonnière, B. (2018). Una nuova geografia del cervello: Funzioni e risorse di un organo sorprendente, Bari: Edizioni Dedalo.

Shors, T. J., Anderson, M. L., Curlik Ii, D. M., & Nokia, M. S. (2012). Use it or lose it: how neurogenesis keeps the brain fit for learning. *Behavioural brain research*, 227(2), pp. 450-458.

Tomlinson, C. A., & Murphy, M. (2015). *Leading for differentiation: Growing teachers who grow kids*. ASCD.

Van Praag, H., Christie, B.R., Sejnowski, T.J. & Gage, F.H. (1999). Running enhances neurogenesis, learning, and long-term potentiation in mice, «*Proceedings of the National Academy of Sciences*», 96, 23, pp. 13427-13431.