NEUROSCIENCE AND COGNITIVE IMPROVEMENT FOR INCLUSION: COGNITIVE MOTOR TRAINING

NEUROSCIENZE E MIGLIORAMENTO COGNITIVO PER L'INCLUSIONE: IL COGNITIVE MOTOR TRAINING

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ABSTRACT

The hypothesis is examined that the inclusion of people can be significantly conditioned by the possible methodological and scientific alliances of neuroscience for cognitive improvement also through Cognitive Motor Training. The aim of the research, carried out through a sample of 406 students in the month of May 2024 during the attendance of training courses qualifying for 30 CFU Ex Art. 13, is to understand the reflections on teachers' awareness.

Si prende in esame l'ipotesi che l'Inclusione delle persone può essere significativamente condizionata dalle possibili alleanze metodologiche e scientifiche delle neuroscienze per il miglioramento cognitivo anche attraverso il Cognitive Motor Training. Scopo della ricerca, svolta attraverso un campione di 406 studenti nel mese di maggio 2024 dei percorsi formativi abilitanti 30 CFU Ex Art. 13, è comprendere le riflessioni sulle consapevolezze dei docenti.

KEYWORDS
Neuroscience; cognitive gain; inclusion; scientific-professional chain; CMT.
Neuroscienze; miglioramento cognitivo; inclusione; filiera scientifico-professionale; CMT.

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Introduction

Neuroscience discoveries work to improve teaching and learning paths, understanding the mechanisms of functioning such as memory and attention, which can be implemented through educational and teaching strategies. Neuroscience can therefore contribute to improving performance in the workplace and in sports, since cognitive training activities can functionalize behavior, reducing stress and improving decision-making skills in high-pressure situations (Vincent & Jane, 2018). Furthermore, it could also help to work in favor of mental well-being, reducing the incidence of mental disorders such as depression and anxiety (Singh, 2024). There are studies that hybridize neuroscience and technologies to allow people to interact with external devices using only brain signals, generating significant opportunities for people with disabilities, allowing them to communicate and control devices with their thoughts (Dye et al., 2019). The close intertwining of neuroscience with cognitive enhancement represents a field rich in potential, with applications that can significantly improve the quality of life and human capabilities, addressing both cognitive and emotional challenges in an innovative and scientifically validated way. A strategy representative of the scientific and professional alliance that is characterized by its uniqueness in being one of the few treatments where the study of the various ways of applying CMT has produced positive results throughout the lifespan, as well as for its pluralism in having developed in different geographical areas, in multiple scientific and professional sectors and with different technologies and fields of application. This is essential to knowing to include (Giaconi & Capellini, 2022). Its conceptual place must be understood through the theory it is accompanied by, professional practices and emerging research for inclusive action (Aiello & Giaconi, 2024). CMT is transversal and its disciplinary scope refers to multiple behavioral sciences and professions, although connections with intentional and scientifically committed professional interventions to the sense of care and well-being are privileged. Cognitive Motor Training is a topic on which a growing international attention converges and recent research and professional applications that have also involved Italy explore a series of reasoning, such as:

- cognitive control and sport;
- decision-making processes;
- influence of a dedicated cognitive-motor protocol;
- cortical connectivity;
- executive functions and attention;
- neuroactivation;
- neurophysiological and neurocognitive mechanisms;

• interactive modes of functioning and physiology and effects;
• neuromuscular strength.
It is a functionalizing cognitive action and finds wide confirmation in the therapies of people with disorders and disabilities, as well as in pathologies, achieving important training gains in a relevant series of aspects, such as socialization and savoring. Therefore, its benefits pervade the processes of building happiness and the self for inclusion. This essay aims to explore how scientific alliances, in this case concretized in CMT, are perceived by future professionals of educational institutions.

1. Neuroscience and CMT

Functional habilitation is a complex action of the mind and scientists deal with it in a trans-disciplinary framework (Morin, 2000). We can now reflect on a series of scientific and neuroscientific devices, using the accounts of scholars who have elaborated the explorations of the possible functional dimensions of CMT in light of the alliance between neuroscience and cognitive enhancement, whose expansion finds a horizon of meaning in the scientific representation of the construct of functionality. Given the relationship between one's cognitive abilities and numerous factors such as educational and professional outcomes (Dear et al., 2007), socioeconomic status and stress levels (Evans & Schamberg, 2009), and happiness (Koval et al., 2013), the idea that cognitive performance can be improved is extremely attractive.
Pioneering studies on CMT can be traced back to authors such as:
- Richard A. Schmidt, who makes fundamental contributions to the field of motor learning;
- Timoty D. Lee, who specified the interest because he has conducted studies on cognitive-motor training;
- Gabriel Wulf, who contributes to the implementation of the theory of implicit training and its effects on motor learning.
There are then a series of studies that explore the effects of CMT in pediatric age.
Santner et al. (2018) seek to understand whether training affects brain development, although it is still unclear what type of exercise can induce higher cognitive effects and whether concomitant mental engagement provides additional efficacy. The study aims to understand the motor and cognitive effects in subjects aged 6 to 10 years, resulting from a 9-week habilitative action. Training includes the automation of coordination exercises with concomitant mental tasks and multisport exercises with and without mental tasks. Benefits were found for the combination of automated coordination exercises with mental tasks.

There is further research by a group of scholars from Basel who are interested in the effects of CMT, focusing their interest on the relationship between brain functions and anticipation (Lucia et al, 2021).

Walsh (2014) wonders if sport is the brain's greatest challenge. He believes the application of cognitive neuroscience to sport science leads to innovative exercises such as cognitive-motor training. Further clarifications come from the research of Hotting et al. (2013), who believe that exercise has beneficial effects on executive function and on people's memory: neural systems change through exercise because they allow the maintenance of cardiovascular fitness essential for any long-term benefit on cognition. This form of cerebrovascular activity generated by CMT allows the human brain to change based on needs, altering its functional and structural properties: *neuroplasticity is activated* which translates into learning and the acquisition of skills.

The scientific implications are many and benefits are hypothesized for neurogenesis, synaptogenesis , angiogenesis, which are all fundamental to the release of neurotrophins necessary for the neural mechanisms that mediate the cognitive effects of physical exercise. So in summary:

- neurocognitive benefits are achieved if physical activity is combined with cognitive activity simultaneously;
- we can maintain the neurocognitive benefits induced by physical exercise if we also work on our cardiovascular fitness level.

A group of scientists study psychomotor efficiency from the optimal point of view, that is, they observe expert athletes who possess refined attention strategies and an efficient motor program (Chuen et al. 2023). To understand their performance, they interrogated the brain, using electroencephalogram, exploring frontal theta power, left temporal alpha power, sensorimotor rhythm and frontocentral alpha power and power. The investigation aims to understand the positive relationship between these neural processes and the probability of effective cognitive-motor performance. The results revealed that concomitant increases in frontal theta and left temporal alpha were contextual to adequate performance, as well as the concomitant and coordinated activation of motor processes implicated by sensorimotor rhythm and central alpha suggest a greater probability of success. This contribution highlights that a dedicated distribution of attention and an adequate elaboration of the motor program are fundamental cognitive aspects for superior cognitive-motor performance for experts.

Mourea, Morrison and Conway (2015) work on a new approach to cognitive training based on complex motor activities. Through a randomized controlled design study, participants were assigned to only one of three conditions:

- aerobic exercise;
- working memory training,
- sport designed to include both physical and cognitive demands.

The groups did not exercise for 8 weeks, many were the benefits especially in the designed sport group that achieved important global cognitive gains, highlighting how complex motor activities are essential to improving cognition and reducing heart rate and blood pressure. Again if we investigate the effectiveness of complex motor activities to improve cognition, through the complex coordination of the designed sport, then we can find improvements in working memory capacity and spatial ability.

Then there are the investigations of the CMT developed with technology. The investigation moves on the relationship between cognition , sport and mental rotation. They are Pietsch, Böttcher and Jansen (2017), who study precisely how long-term physical activity in specific sports activities can change the quality of mental rotation performance. Through the study of *Life Kinetik* , or a movement program with tasks of cognition and motor coordination effective on the mental rotation performance of 44 school-age children, showing a significant increase in mental rotation capacity. Mental rotation is an essential aspect for the cultural access of subjects to rhetorical figures, in particular to metaphors and to understanding in general, examples of which are idioms and proverbs .

Hayakawa and Kobayashi in Japan conducted several studies and initially explored the effects of training young people with intellectual disabilities with the aim of improving their motor skills (Hayakawa and Kobayashi, 2008; 2011). Then later Hayakawa and Kobayashi (2013) study the effects of CMT on intellectual disability of subjects between 12 and 21 years of age, who were subjected to a training course to improve motor skills, endurance, muscle strength and motor balance using fifteen types of training machines. The results were measured mainly using observation of participants' movements, fitness tests, questionnaires and video monitoring. Their training improved their health and especially produced effects on social skills, such as the ability to self-control their behaviors and accept adjustments resulting from instructions from others, generating cooperative interaction. The technology was developed by Dr. Kobayashi and the word cognitive was used for training because cognitive abilities related to the control of body movements are a fundamental requirement for adequately performing machine exercises, especially for sprint training machines and elliptical orbit *power bike machine, here the* ipsilateral foot, knee, hip and shoulder. Nervous control, different from typical motor behaviors, is used in the *ipsilateral* movement of the

lower and upper extremities of the body and is initially difficult for most individuals, but becomes easier as focused attention is implemented.
Studies show that individuals with intellectual disabilities have limited capacity for muscular effort when it is necessary to concentrate force in a prescribed manner.
Casella et al. They conducted confirmatory studies of the benefits obtained on executive functions for aspects of the cognitive system of human functioning through the application of CMT on adults and elderly people. Through psychokinetic CMT, the positive outcomes of the treatment on executive functions are confirmed, observable through those behaviors that express planning and visual search skills of young soccer players. The researchers conclude that CMT is effective for improving planning skills and visual search skills, even in children (Casella et al., 2022).
Very interesting are the studies by Kasatkin et al. (2024) who conducted a prospective pilot study to evaluate the feasibility and effects of the cognitive-motor intervention on the cognitive and motor skills of children with cognitive deficits between 7 and 18 years of age who survived posterior fossa tumors and who had completed the specific primary treatment. The researchers generated work sessions and the training included:
- general motor training - GMT;
- graphomotor training – GT;
- cognitive-motor training - CMT.

The results paint an encouraging picture as the authors detect stable and significant improvements in visuospatial working memory , visual attention, eye-hand coordination, semantic verbal fluency, auditory-motor synchronization, reaction time and a decrease in the rate of ataxia, calling for further research.
In Italy, CMT boasts the professional figure of the Cognitive Motor Trainer and its professional training is based on the Cognitive and Motor Theory (Crispiani , 2023) with three lines of action: neuro-activation, basic instrumental enhancement for reading, writing, mathematical skills, motor skills and language and disciplinary or cultural enhancement. CMT is characterized by a series of driving activities with intensity for greater neurophysiological activation and the dynamization of action sequences in constancy and fluidity. Through the execution of a conscious and automatic activity of thought sequences, the enhancement of the function and the organ is generated. The simultaneous, coordinated and constant activation of functions is a reason for reorganization of cortical flows and enhancement of their effectiveness. The CMT is developed and coordinated by the Itard Video Motor Training, Champion LIRM working method for intensive reading and *Speed Motor*

and the Champion Pressing book (Crispiani & Palmieri, 2023) Training which intensifies the CMT.

2 The Method and Research Tools

The questions are: How can cognitive-motor training (CMT) influence cognitive and motor improvement in educational and therapeutic contexts? Are teachers aware of it? Are there misalignments?

The study aims to offer a possible description and interpretation of the trans-disciplinary and trans-professional realities through the involvement of 406 students, who in May 2024 were attending the 30 CFU qualifying training courses Ex Article 13, through a recurring institutional research cycle. The self-designed questionnaire was disseminated through the Survey Monkey platform (SurveyMonkey Inc.) and distributed through dedicated newsletters.

They are characterized by great geographical heterogeneity and disciplinary cultural plurality and by having graduated in different academic years. The sample completed the self-compiled questionnaire on the application of neuroscience in cognitive enhancement and CMT. Participants were post- graduate students who acquired their bachelor's degree in different academic years. Regarding gender, the majority of participants were female (90.25%), followed by male (9.00%), with a small percentage of undeclared preferences.

The research was based on the data matrix with a self-structured survey, containing multiple choice and open-ended questions that explored topics such as:

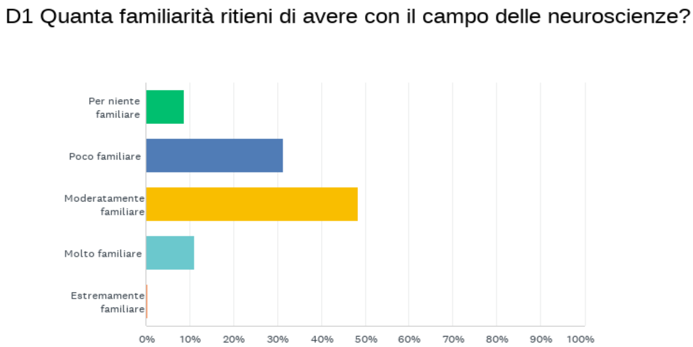
- familiarity with neuroscience and CMT;
- opinions on the role of neuroscience in cognitive enhancement;
- specific interests in the area of cognitive improvement, such as memory , attention, problem solving, language, motor skills, learning;
- opinions on the impact of neuroscience on the quality of teaching;
- most promising research opportunities;
- potential benefits of integrating neuroscience into various educational treatments;
- use of neuroscientific knowledge in professional educational practices.

3. Results

In general terms, from the research between the abstract actors identified and the concrete factors detected, because empirically observable, there exists, as we can observe (Fig. 1), the following semantic representation relationship.

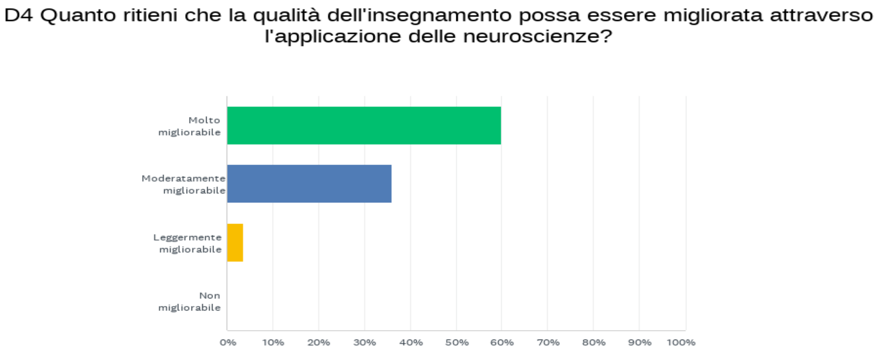
(Fig. 1)

The results show that 79.96% of the students are not familiar with Cognitive Motor Training, while 16.46% are moderately familiar and 2.95% are very familiar, while only 0.63% have extreme familiarity. As we can see, the participants believe they have a certain degree of familiarity with neuroscience (Graph . 2).



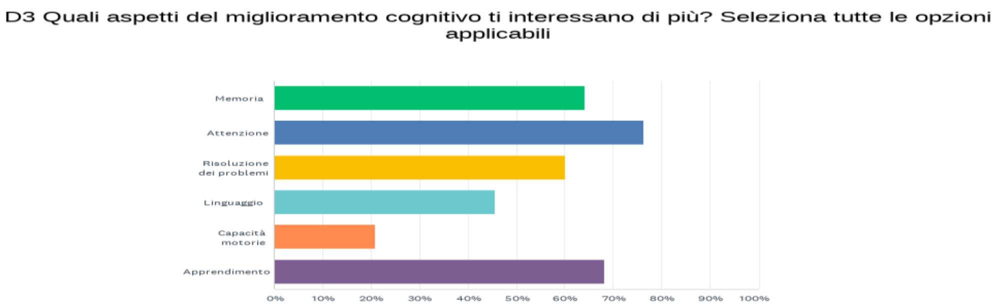
(Graph. 2)

The survey results indicate that the majority of participants believe that neuroscience can play a significant role in cognitive improvement, with 51.72% answering “Yes, definitely” and 44.58% answering “Probably yes” (Graph 3).



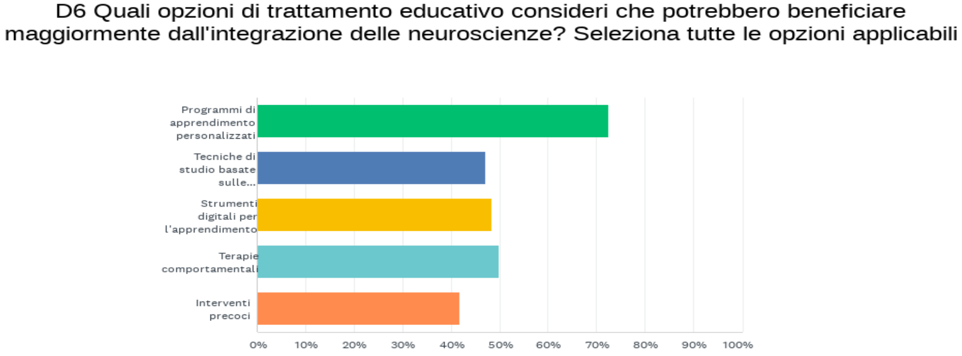
(Graph. 3)

Participants showed strong interest in various aspects of cognitive improvement, with memory (64.29%) and attention (76.35%) as the areas of greatest interest (Graph . 4).



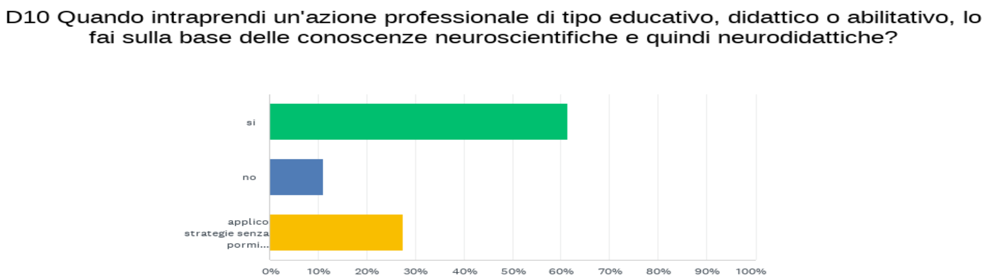
(Graph. 4)

A high percentage of participants (59.95%) believe that the quality of teaching can be greatly improved through the application of neuroscience. In addition, participants indicated that personalized learning programs (72.46%) and neuroscience-based study techniques (47.15%) are the areas that could benefit the most from the integration of neuroscience (Graph . 5).



(Graph. 5)

The research also highlights a high level of interest in the implications and effects of neuroscience on cognitive improvement, with 92.06% of participants expressing interest in learning more, as a large number of teachers believe they base their teaching and pedagogical actions on neuroscientific constructs (Graph. 6).



(Graph. 6)

4. Discussion

The initial data are controversial since more than half of the respondents use neuroscientific knowledge in their educational activities, while a significant part applies strategies without explicitly considering the neuroscientific basis and very few, for example, know CMT. Reflections on the results of this survey regarding neuroscience and cognitive improvement and the case of CMT highlight a non-coherent awareness between the levels of familiarity with neuroscience and with the specific case of CMT. This should make us think that there is a great resonance of neuroscientific constructs, but that the scientific and professional chain has not acquired such robustness to be well profiled. In any case, it is interesting to note how this diversity influences their opinions on the potential of neuroscience in cognitive improvement and opens up new cognitive and applicative sensibilities. Most of the respondents are optimistic. Over half firmly believe in the significant role of neuroscience, and almost all the others are inclined to think that they can have a positive impact, especially for memory and attention, which emerge as the main points of interest. Problem solving, language and motor skills and learning follow, showing a broad interest in various cognitive areas. The perception is equally positive regarding the potential of neuroscience to improve the quality of teaching: a significant majority believe that neuroscience can greatly improve the quality of teaching, while a small percentage believe that the impact may be minimal. There is great interest in personalized learning programs, neuroscience-based study techniques, digital tools, behavioral therapies and early interventions. These areas seem to offer many possibilities for future development. The survey shows us that the survey participants believe in the great benefits of integrating neuroscience into personalized programs, study techniques, digital tools, behavioral therapies and early interventions. This indicates a clear preference for diverse and neuroscience-based educational approaches. There is a decisive interest in learning more about neuroscience and cognitive enhancement , especially the participants ask to learn more about the implications and effects of neuroscience on cognitive enhancement, indicating a strong desire to continue learning in this field.

Conclusions

This study demonstrates a broad consensus among students across disciplines on the importance of neuroscience in cognitive enhancement and teaching. Participants are interested in various aspects of cognitive enhancement and believe in integrating neuroscience into educational practices, which however must be adequately profiled, as a misalignment between neuroscientific information, applications and reflection is evident. These results suggest the need for further research and practical applications to better transfer the acquisitions of the neuroscientific field into the educational and didactic context.

References

Aiello, P., & Giaconi, C. (2024). L’agire inclusivo. Brescia: Morcelliana.

Casella, A., Ventura, E., & Di Russo, F. (2022). The Influence of a Specific Cognitive-Motor Training Protocol on Planning Abilities and Visual Search in Young Soccer Players. Brain sciences, 12(12), 1624.

Chueh, T. Y., Lu, C. M., Huang, C. J., Hatfield, B. D., & Hung, T. M. (2023). Collaborative neural processes predict successful cognitive-motor performance. Scandinavian Journal of Medicine & Science in Sports, 33(3), 331-340.

Crispiani, P., & Palmieri, E. (2023). Champion Pressing. Chiaravalle: Itard.

Deary, I. J., Strand, S., Smith, P., & Fernandes, C. (2007). Intelligence and educational achievement. Intelligence, 35(1), 13–21.

Dye, M. W., Green, C. S., & Bavelier, D. (2009). The development of attention skills in action video game players. Neuropsychologia, 47(8-9), 1780–1789.

Evans, G. W., & Schamberg, M. A. (2009). Childhood poverty, chronic stress, and adult working memory. Proceedings of the National Academy of Sciences, 106(16), 6545–6549.

Giaconi, C., & Capellini, S. A. (2015). Conoscere per includere. Riflessioni e linee operative per professionisti in formazione. Milano: FrancoAngeli.

Hayakawa, K., & Kobayashi, K. (2011). Physical and motor skill training for children with intellectual disabilities. Perceptual & Motor Skills, 112(2), 573–580.

Hayakawa, K., & Kobayashi, K. (2013). Effect of a 5-Year Cognitive Motor Training Program on Intellectually Disabled Youth. Innovative Teaching, 2(4).

Hotting, K., & Röder, B. (2013). Beneficial effects of physical exercise on neuroplasticity and cognition. Neuroscience & Biobehavioral Reviews, 37(9B), 2243-2257.

Kasatkin, V. N., Romanova, E. N., Glebova, E. V., Deviaterikova, A. A., & Tolchennikova, V. V. (2009). Gli effetti di un programma di esercizi su diverse abilità associate alle prestazioni di guida negli adulti anziani. Accident Analysis & Prevention, 41, 90-97.

Koval, P., Pe, M. L., Meers, K., & Kuppens, P. (2013). Affect dynamics in relation to depressive symptoms: variable, unstable or inert?. Emotion, 13(6), 1132-1141.

Lucia, S., Bianco, V., Boccacci, L., & Di Russo, F. (2021). Effects of a Cognitive-Motor Training on Anticipatory Brain Functions and Sport Performance in Semi-Elite Basketball Players. Brain Sciences, 12(1), 68.

Moureau, D., Morrison, A. B., & Conway, A. R. A. (2015). An ecological approach to cognitive enhancement: Complex motor training. Acta Psychologica, 157, 44-55.

Morin, E. (2000). The well-made head: Reforming education and reforming thought. Milano: Raffaello Cortina Editore.

Pietsch, S., Böttcher, C., & Jansen, P. (2017). Cognitive Motor Coordination Training Improves Mental Rotation Performance in Primary School-Aged Children. Mind, Brain and Education, 11(4), 176-170.

Santner, A., Kopp, M., & Federolf, P. (2018). Partly randomised, controlled study in children aged 6-10 years to investigate motor and cognitive effects of a 9-week coordination training intervention with concurrent mental tasks. BMJ Open.

Singh, I. (2024). The use and misuse of smart drugs for cognitive enhancement. Association for Psychological Science.

Vincent, J., & Jane, S. (2018). Cognitive Enhancement: Unanswered Questions About Human Psychology and Social Behavior. Science and Engineering Ethics.

Walsh, V. (2014). Is sport the brain's biggest challenge?. Current Biology, 24(18), 859-860.