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MUSICAL SKILLS AND PERCEIVED VIVIDNESS OF IMAGERY: DIFFERENCES BETWEEN MUSICIANS AND UNTRAINED SUBJECTS

di
Santo F. Di Nuovo, *Anita Angelica*

1. *Introduction*

1.1. *Neuropsychology of music*

Neuropsychological studies have demonstrated that musical processes are represented throughout the brain, involving widely diffuse cerebral areas: i.e., auditory, visual, cognitive, affective, memory, and motor systems[1]. This activation involves also mental imagery, intended as reproduction – and original interpretation, if requested – of cognitive contents and/or motor behaviors not immediately present in the actual sensory-motor perception, using working memory and rehearsal[2]. Kinesthetic imagery, in particular, activates neuronal structures necessary for the execution of the movements and the learning of new motor skills[3]. The ability of reconstructing in images some cognitive and emotional features of memory may be useful to foster the expression of musical activities[4]; in fact, they require the mental representation of musical sounds and/or movements

[1] D. Hodges, *Neuromusical research: A review of the literature*, in *Handbook of music psychology*, ed. by D. Hodges, San Antonio, IMR Press, 1996, pp. 203-290; R.I. Godøy, H. Jørgensen, *Musical Imagery*, Lisse, The Netherlands, Swets & Zeitlinger, 2001; S. Koelsch, *Brain and Music*, New York, Wiley, 2012.

[2] A. Paivio, *Imagery and verbal processes*, New York, Holt, Rinehart and Winston, 1971; S.M. Kosslyn, *Image and Mind*, Cambridge, MA, Harvard University Press, 1980; S.M. Kosslyn, W.L. Thompson, G. Ganis, *The case for mental imagery*, New York, Oxford University Press, 2006.

[3] A. Pascual-Leone, *The brain that makes music and is changed by it*, in *The cognitive neuroscience of music*, ed. by I. Peretz, R. Zatorre, Oxford, Oxford University Press, 2003, pp. 396-409.

[4] A.D. Baddeley, R.H. Logie, *Auditory imagery and working memory*, in *Auditory imagery*, ed. by D. Reisberg, Hillsdale, NJ, Erlbaum, 1992, pp. 179-197; A.R. Halpern, *Musical aspects of auditory imagery*, in *Auditory Imagery*, ed. by D. Reisberg, Hillsdale, NJ, Erlbaum, 1992, pp. 1-27.

related to music[5], which can be so accurate as to recreate in his mind many aspects of the real stimulus[6].

Hearing by the 'ear of the mind', i.e. musical imagery, and performing music, have specific neurobiological substrates, since they activate neural circuitry involving auditor and motor cortex analogous to listening to music and/or perform it. Since musical imagery refers to the experience of replaying music through the imagination, it may share a neural substrate in the brain with perceptual musical processes[7].

Goldenberg et al.[8] studied the contributions of occipital and temporal brain regions in activating visual and acoustic imagery; components of imagery of complex sounds have been detected[9]. Also imagined musical timbres and familiar tunes, and the anticipation of sound sequences, have specific neural correlates[10].

In an embodied cognition view, each imagined movement could correspond to the execution of the movement itself[11]. Imagining the music determines an activation not only of the auditory cortex, comparable to that determined by listening, but also of the motor cortex, as well as if the imagined movements are put in place[12].

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[5] P.E. Keller, *Mental imagery in music performance: underlying mechanisms and potential benefits*, in «Annals of the New York Academy of Sciences», 1252 (2012), pp. 206-213.

[6] P. Janata, K. Paroo, *Acuity of auditory images in pitch and time*, in «Perception and Psychophysics», 68 (2006), pp. 829-844; A.R. Halpern, R.J. Zatorre, M. Bouffard, J.A. Johnson, *Behavioral and neural correlates of perceived and imagined musical timbre*, in «Neuropsychologia», 42 (2004), pp. 1281-1292; R.G. Crowder, *Imagery for musical timbre*, in «Journal of Experimental Psychology: Human Perception and Performance», 15 (1989), pp. 472-478; A.R. Halpern, *Memory for the absolute pitch of familiar songs*, in «Memory & Cognition», 17 (1989), pp. 572-581.

[7] R.J. Zatorre, A.R. Halpern, D.W. Perry, E. Meyer, A.C. Evans, *Hearing in the mind's ear: A PET investigation of musical imagery and perception*, in «Journal of Cognitive Neuroscience», 8 (1996), pp. 29-46; R.J. Zatorre, A.R. Halpern, *Mental concerts: Musical imagery and auditory cortex*, in «Neuron», 47 (2005), pp. 9-12.

[8] G. Goldenberg, I. Podreka, M. Steiner, P. Franzen, L. Deecke, *Contributions of occipital and temporal brain regions to visual and acoustic imagery - A SPECT study*, in «Neuropsychologia», 29 (1991), pp. 695-702.

[9] N. Bunzeck, T. Wuestenberg, K. Lutz, H.J. Heinze, L. Jancke, *Scanning silence: Mental imagery of complex sounds*, in «NeuroImage», 26 (2005), pp. 1119-1127.

[10] A.R. Halpern et al., *Behavioral and neural correlates of perceived and imagined musical timbre* cit.; S.C. Herholz, C. Lappe, A. Knief, C. Pantev, *Neural basis of music imagery and the effect of musical expertise*, in «European Journal of Neuroscience», 28 (2008), pp. 2352-2360; A.M. Leaver, J. Van Lare, B. Zielinski, A.R. Halpern, J.P. Rauschecker, *Brain activation during anticipation of sound sequences*, in «Journal of Neuroscience», 29 (2009), pp. 2477-2485.

[11] A.R. Halpern, *Cerebral substrates of musical imagery*, in «Annals of the New York Academy of Sciences», 930 (2001), pp. 179-192; R.W. Gibbs, E.A. Berg, *Mental imagery and embodied activity*, in «Journal of Mental Imagery», 26 (2002), pp. 1-30.

[12] R.J. Zatorre et al., *Hearing in the mind's ear: A PET investigation of musical imagery and perception* cit.; O. Sacks, *Musicophilia: Tales of music and the brain*, London, Knopf, 2007.

Brochard et al.[13] found that in tasks of imagination the musicians had shorter reaction times than non-musicians, and their performance seemed to be reinforced on the long-term by musical expertise. The effect of musical expertise is connected to the neural bases of music imagery[14]; professionals and naïve individuals have different cerebral activation during performances and imagery[15]. These differences could explain the involvement of both motor, auditory and visual-spatial brain regions, demonstrated comparing brain structures of professional musicians and non-musicians[16].

Musically-trained persons have stronger and faster brain responses to musical tasks than untrained subjects, and the primary auditory cortex of musicians is larger[17].

1.2. *Auditory, visual, motor imagery*

As regards the modality of imagery, Aleman et al.[18], demonstrated that the experimental comparison between a group of musicians and non musicians has detected a difference in their auditory imagery abilities: the musicians have achieved better performance in tasks that required the use of auditory images but equal performance in visual tasks. Moreover, expert musicians are particularly able to deduce auditory images from musical notation[19], and to translate images in music[20].

The importance of the process of imaging in musical training has been confirmed[21].

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[13] R. Brochard, A. Dufour, O. Després, *Effect of musical expertise on visuospatial abilities: Evidence from reaction times and mental imagery*, in «Brain and Cognition», 54 (2004), pp. 103-109.

[14] S.C. Herholz et al., *Neural basis of music imagery and the effect of musical expertise* cit.

[15] M. Lotze, G. Scheler, H.R.M. Tan, C. Braun, N. Birbaumer, *The musician's brain: functional imaging of amateurs and professionals during performance and imagery*, in «NeuroImage», 20 (2003), pp. 1817-1829.

[16] C. Gaser, G. Schlaug, *Brain structures differ between musicians and non-musicians*, in «The Journal of Neuroscience», 23 (2003), pp. 9240-9245.

[17] D. Hodges, *Neuromusical research: A review of the literature* cit.; R.I. Godøy, H. Jørgensen, *Musical Imagery* cit.; S. Koelsch, *Brain and Music* cit.

[18] A. Aleman, M.R. Nieuwenstein, K.B. Böcker, E.H. de Haan, *Music training and mental imagery ability*, in «Neuropsychologia», 38 (2000), pp. 1664-1668.

[19] W. Brodsky, A. Henik, B.S. Rubinstein, M. Zorman, *Auditory imagery from musical notation in expert musicians*, in «Attention, Perception, & Psychophysics», 65 (2003), pp. 602-612.

[20] F. Bailes, *Translating the musical image: case studies of expert musicians*, in *Sounds in translation: Intersections of music, technology and society*, ed. by A. Chan, A. Noble, Canberra, Australian National University Press, 2009, pp. 41-59.

[21] A. Aleman et al., *Music training and mental imagery ability* cit.

A study based on experience-sampling methods (ESM), reported that the music students imagine music as a very frequent form of their experience[22].

The musicians can use the mental image in modalities both visual (e.g., when pianists "see" their fingers moving on the keyboard) and auditory (e.g., when a jingle resonates in the mind, creating a "concert of mind"[23]). But also motor imagery is relevant; in general, it refers to mental repetition of simple and complex motor actions that are not associated with actual movement of the body. This allows to assess the consequences of future actions and to prepare the motor system to execution[24].

Motor imagery can be used by professional musicians to improve their performance[25]. The activation of musical images could regard the specific movements to be performed[26]. To confirm this, Haueisen and Knösche[27] have found in the pianists the activation of primary motor regions, corresponding to the finger that they would use to produce a given note, when listening to a piece.

On the other hand, Haslinger et al.[28] observed the activation of different auditory areas when the musicians watched a silent video of someone playing a piano. So the imaginations of musical sounds and of movements relative to playing an instrument seem related.

1.3. *Vividness of imagery*

A relevant variable in musical activities is the vividness of imagery, regarding different sensorial channels, i.e., visual, auditory, motor, and kinaesthetic im-

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[22] F. Bailes, *The prevalence and nature of imagined music in the everyday lives of musical students*, in «Psychology of Music», 35 (2007), pp. 555-570.

[23] R.J. Zatorre, A.R. Halpern, *Mental concerts: Musical imagery and auditory cortex* cit.

[24] M. Jeannerod, *Mental imagery in the motor context*, in «Neuropsychologia», 33 (1995), pp. 1419-1432;

M. Jeannerod, *Neural simulation of action: a unifying mechanism for motor cognition*, in «NeuroImage», 14 (2001), pp. 103-109; I.G. Meister, T. Krings, H. Foltys, B. Boroojerdi, M. Müller, R. Töpper, A. Thron, *Playing piano in the mind-an fMRI study on music imagery and performance in pianists*, in «Cognitive Brain Research», 19 (2004), pp. 219-228.

[25] A. Solodkin, P. Hlustik, E.E. Chen, S.L. Small, *Fine modulation in network activation during motor execution and motor imagery*, in «Cerebral Cortex», 14 (2004), pp. 1246-1255.

[26] M. Mikumo, *Motor encoding strategy for pitches of melodies*, in «Music Perception: An Interdisciplinary Journal», 12 (1994), pp. 175-197; H. Petsche, A. von Stein, O. Filz, *EEG aspects of mentally playing an instrument*, in «Cognitive Brain Research», 3 (1996), pp. 115-123.

[27] J. Haueisen, T. Knosche, *Involuntary motor activity in pianists evoked by music perception*, in «Journal of Cognitive Neuroscience», 13 (2001), pp. 786-792.

[28] B. Haslinger, P. Erhard, E. Altenmüller, U. Schroeder, H. Boecker, A.O. Ceballos-Baumann, *Transmodal sensorimotor networks during action observation in professional pianists*, in «Journal of Cognitive Neuroscience», 17 (2005), pp. 282-293.

ages. The vividness as subjective experience represents a core aspect for the quality of imagery[29], represented in terms of similarity to the perceptual but also kinaesthetic experience[30].

The vividness of images is higher in professional musicians[31].

Brodsky et al.[32] quote that a very high percentage of professional musicians claim that they can 'hear' the printed notation, but it was demonstrated that the skill – on the basis of objective measures – could only be found among 33% of professional musicians. The overvaluation of the imagery skill, according to the results of this study, could have been raised from believing that a good musician can/should hear the notation. Therefore, to assess the real ability of visualization in musicians, instruments not directly involving musical activities seem to be more indicated.

The self-report measure of imagery vividness is a reliable and valid assessment of an individual's ability to produce images of movement[33]. The imagery vividness correlates with two objective measures: the activity of the visual cortex, as measured with functional magnetic resonance imaging (fMRI), and the performance in a novel psychophysical task. This proves that individual differences in the vividness of mental images are reliably quantifiable[34].

2. *Aims and hypotheses*

2.1. *Aims of the study*

The quick review of the literature presented above suggests that imagery is relevant in musical processes and training, since a greater facility in producing

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[29] T.L. Hubbard, *The importance of a consideration of qualia to imagery and cognition*, in «Consciousness and Cognition», 5 (1996), pp. 327-358.

[30] T.L. Hubbard, *Auditory imagery: Empirical findings*, in «Psychological Bulletin», 136 (2010), pp. 302-329; S. Hishitani, T. Miyazaki, H. Motoyama, *Some mechanisms responsible for the vividness of mental imagery: Suppressor, closer, and other functions*, in «Journal of Mental Imagery», 35 (2011), pp. 5-32.

[31] M. Lotze et al., *The musician's brain: functional imaging of amateurs and professionals during performance and imagery* cit.; S.C. Herholz, A.R. Halpern, R.J. Zatorre, *Neuronal correlates of perception, imagery, and memory for familiar tunes*, in «Journal of Cognitive Neuroscience», 24 (2012), pp. 1382-1397.

[32] W. Brodsky et al., *Auditory imagery from musical notation in expert musicians* cit.

[33] A. Isaac, D.F. Marks, D.G. Russell, *An instrument for assessing imagery of movement: the vividness of movement imagery questionnaire (VMIQ)*, in «Journal of Mental Imagery», 10 (1986), pp. 23-30.

[34] X. Cui, C.B. Jeter, D. Yang, P.R. Montague, D.M. Eagleman, *Vividness of mental imagery: Individual variability can be measured objectively*, in «Vision Research», 47 (2007), pp. 474-478.

and visualizing mental images is conceived to be essential for the coordination of thoughts and movements required for the performance of music (not only for listening to it).

But while auditory modality is well-established in the literature results regarding imagery in musicians[35], the visual-motor modality of imagery has been less studied, both with self-reported measures of vividness and with specific visual-motor visualization tasks. In our study the comparison between musicians and non trained individuals will be focused on these aspects of visuo-motor imagery processes.

2.2. *Hypotheses*

A greater capacity in motor visualization was hypothesized in professional musicians than in non-musicians, in self-reported measures of vividness of motor images and in a task of visual-motor visualization performance.

We hypothesized also that the abilities of visualizing mental images are differentiated according to the kind of musical performance specifically trained and practiced.

3. *Method*

3.1. *Sample*

A sample of 102 participants was involved in the study, composed of both expert musicians and individuals never involved in specific musical learning or practice.

The musician group included 51 participants, 28 men and 23 women, age range 18-63, mean age 30.33 (standard deviation 9.97); mean years of education 14.76 (standard deviation 2.53); mean years of musical practice 12.53 (standard deviation 9.48). They were recruited among musicians teaching in Academies of music and students with many years of specific musical training.

Among them, 15.69% were singers; the others were players of strings (33.33%), wind (21.57%), piano (19.61%), and percussion (9.80%) instruments.

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[35] A.R. Halpern, *Musical aspects of auditory imagery* cit.; A. Aleman et al., *Music training and mental imagery ability* cit.; W. Brodsky et al., *Auditory imagery from musical notation in expert musicians* cit.; I.G. Meister et al., *Playing piano in the mind-an fMRI study on music imagery and performance in pianists* cit.; B. Haslinger et al., *Transmodal sensorimotor networks during action observation in professional pianist* cit.; R.J. Zatorre, A.R. Halpern, *Mental concerts: Musical imagery and auditory cortex* cit.

In the musicians group, the time elapsed since the beginning of musical activities was also recorded, to allow analyses pertinent to this variable.

The comparison group of untrained participants, extracted by students and personnel of other high-formation structures, was accurately matched by gender, age and education: 51 subjects, 28 men and 23 women, age range 18-58, mean age 30.08 (standard deviation 9.76); mean years of education 14.82 (standard deviation 2.39).

3.2. *Instruments*

The following tests were administered both to musicians and non musicians:

3.2.1. *Vividness of Movement Imagery Questionnaire* (VMIQ)[36]. The VMIQ is a questionnaire aimed to assess the subjective perception of vividness in mental imaging of movement. It consists of 24 items, divided into 6 groups of 4 items each, regarding:

– body movement (1-4)
– movements that require the use of hands or feet (5-8)
– movements that require a certain control (9-12)
– movements exerted on objects (13-16)
– movements of balance (17-20)
– movements of loss of control (21-24).

The participants are asked to create a mental imagery of the movement described by the item, attributing the role of the agent of the action to himself or to a third person, and to assess the vividness of that image on a 5-point scale: 1 (no image); 2 (vague and blurred image); 3 (image fairly clear and vivid); 4 (image clear and vivid); 5 (image perfectly clear and vivid).

3.2.2. As additional performance task linked to visual-motor imagination was added, i.e. the specific subtest *Imagined paths* from the *Mental Imagery Test* (MIT)[37]. The task, derived from Kosslyn's studies[38], requires to visualize a small ball moving in different directions, following a suggested path in the imagined space, and saying if at the end of the route the ball will end up above or below the starting point, or at the same level. The score is the sum of correct answer for each of the 8 trials composing the task, adding one point for the success in the

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[36] A. Isaac, D.F. Marks, D.G. Russell, *An instrument for assessing imagery of movement: the vividness of movement imagery questionnaire (VMIQ)* cit., pp. 23-30.

[37] S. Di Nuovo, S. Castellano, M. Guarnera, *Mental Imagery Test*, Florence, Hogrefe, 2014.

[38] Reported in P.J. Hampson, D.F. Marks, J.T.E. Richardson, *Imagery: current developments*, London, Routledge, 1990.

last three more complex paths, including more than 4 movements of the ball. The reliability of this test is .78.

In both the instruments references to musical activities were not present, to avoid biases due to the specific field of experience in musicians group[39].

3.3. *Procedure*

The administration of the instruments took place for both groups in individual sessions, lasting about 15 minutes.

All participants were evaluated in places that could allow privacy, in a face to face setting. They completely understood the nature of the research and provided informed consent prior to participation.

Statistical analyses of the data included Pearson correlation, Student's *t* and covariance analysis for assessing differences between groups. In these latter cases, an effect size measure was also computed (i.e., Cohen's *d*, R^2).

4. *Results*

Preliminary correlation analysis between the *vividness of imagery* score and the *Imagined Path* task shows little covariation between that the two modalities of measuring imagery: r=0.16 in musician group, r=0.03 in controls (these correlations were not statistically significant: p>0,05).

The significance of the differences between the scores in the two groups (musicians vs non musicians) was assessed by means of the Student's *t*. Results are shown in table 1.

Table 1 - *Differences between the scores in MIT and VMIQ tests in musicians and control participants*

	Musicians		Controls		Statistical
	Mean	*St.err.*	*Mean*	*St.err.*	Significance test *(t)* and effect size *(d)*
Vividness of imagery	96.78	2.21	90.27	2.29	t=2.04*; d=0,40
Imagined paths	9.35	0.29	8.51	0.41	*t=1.68*; *d=0.33*

d.f =100, * p<.05

[39] W. Brodsky et al., *Auditory imagery from musical notation in expert musicians* cit.

For the vividness of motor images the difference is statistically significant, in the expected direction, i.e. the expert group reports more vivid images than untrained controls.

Interestingly, in the trained group the perception of vividness is related with the time elapsed from the beginning of the specific musical training (correlation with the number of years elapsed in training and musical practice: $r = 0.32$, d.f.= 49, $p<0.05$), while this correlation is non significant for imagery tasks ($r = -0.08$).

A specific analysis, within the expert group, was aimed at exploring the incidence of the type of musical activity, using the amount of experience as covariate.

The results of the analysis of covariance are shown in table 2.

Table 2 - *Differences between the scores in MIT and* VMIQ *tests in musicians group, according to type of musical activity (covariate: number of years of musical practice)*

	Type of musical activity						
	Singers (n=8)	Piano (n=10)	Strings (n=17)	Wind (n=11)	Percussion (n=5)	An. of covariance (*d.f.*= 4,1,45)	
	Mean ± St.err.	*Mean ± St.err.*	*Mean ± St.err.*	*Mean ± St.err.*	*Mean ± St.err.*	*F (effect)*	*F (covariate)*
Vividness of imagery	97.63 ±5.31	100.92 ±4.74	90.83 ±3.63	97.78 ±4.53	105.24 ±6.72	1.28 p=0.29	5.04 p=0.03*
Imagined paths	6.83 ±1.01	7.97 ±0.90	9.05 ±0.69	9.76 ±0.86	7.71 ±1.28	1.55 p=0.20	0.85 p=0.36

R^2=0.44 for Vividness, R^2=0.38 for Imagined Paths * p<.05

More vivid kinaesthetic images are reported by percussionists, compared with other subgroups; but the overall difference is not significant, due to the small number in the subsamples. The covariate is significant for vividness of imagery. For this component of imagery, the incidence of the amount of musical practice confirms that training and experience are relevant for differentiating the ability to recall and use images by musical experts.

Differences are less relevant for imagined paths, and no effect for amount of practice was demonstrated. While the overall ANOVA was not significant, an interesting trend is shown: wind and strings players have higher scores than others instruments, and singers show the lowest scores.

5. *Discussion and conclusions*

Potential benefits of mental imagery in music teaching, learning and performance, have been underlined in literature[40]: the 'ear in the mind'[41] may be fostered by an appropriate imaging, and in turn, imagery can be trained to enhance its contribution to musical skills. But a preliminary assessment is needed to implement specific training of mental imagery, aimed at exploring the individual's skills in performing imagery tasks and in visualizing vivid images in visual and kinesthetic modalities. These two components of imagery may represent a discriminant between expert musicians vs untrained persons.

Subjective and objective imagery measures generally may be not associated[42], suggesting that they do not tap the same cognitive processes. Our study confirmed the small correlation between that the two modalities of assessing imagery; and showed that trained and expert musicians have more vivid motor imagery than untrained counterparts, but there were no differences in the objective measure of imagery, confirming results found by Aleman et al.[43]. This form of imagery in our study involved kinesthetic besides visual imagery activities, differentiating expert musicians from untrained individuals beyond the already well known difference in auditory imaging.

In particular, the percussionists have reported more vivid images than the other subgroups of musicians: perhaps, since motor imagery was prevalently assessed in our study, this result can be explained considering that percussionists use gross motor movement – easier to be visualized – more than all other players.

But the two component of imagery, i.e. performing imagery tasks and visualizing vivid images, may show differences within the same participants, regardless of their experience in performing music.

A limitation of the correlational study is the impossibility to take into account the starting level of imagery skills of musicians before training, to infer if this variable improves the musical expertise, or vice versa it could result from the training itself. Only a longitudinal study could test these hypotheses, and conclude about the usefulness of planning and implementing specific trainings aimed at enhancing the ability to produce and/or play music using the 'mind's ear'.

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[40] P.E. Keller, *Mental imagery in music performance: underlying mechanisms and potential benefits* cit.

[41] M. Schürmann, T. Raij, N. Fujiki, R. Hari, *Mind's ear in a musician: Where and when in the brain*, in «NeuroImage», 16 (2002), pp. 434-440.

[42] A. Lequerica, L. Rapport, B.N. Axelrod, K. Telmet, R.D. Whitman, *Subjective and objective assessment methods of mental imagery control: Construct validation of self-report measures*, in «Journal of Clinical and Experimental Neuropsychology», 24 (2002), pp. 1103-1116.

[43] A. Aleman et al., *Music training and mental imagery ability* cit.

ABSTRACT

Fra i processi implicati nella percezione e nelle prestazioni musicali, l'immaginazione mentale è rilevante per l'esecuzione dei movimenti e per apprendere nuove capacità motorie. Una buona vividezza delle immagini motorie viene ipotizzata nei musicisti professionisti rispetto ai non musicisti.

Sono stati coinvolti nello studio 102 partecipanti, 51 esperti musicisti e 51 senza specifica istruzione e pratica musicale, appaiati per genere, età e anni di scolarizzazione. Nel gruppo dei musicisti sono stati rilevati il tempo trascorso dall'inizio della pratica e il tipo di attività musicale specializzata. Come misure della percezione immaginativa motoria sono stati utilizzati il *Vividness of Movement Imagery Questionnaire* (VMIQ) e un test di 'percorsi immaginati'.

I risultati dimostrano che le componenti soggettive dell'immaginazione (visualizzazione di immagini cinestesiche) discriminano i musicisti esperti dai non musicisti, e che gli anni di pratica costituiscono una rilevante variabile covariata.

Among the processes involved in musical perception and performance, mental imagery is relevant for the execution of movements and for learning new motor skills. A greater vividness of motor images was hypothesized in professional musicians than in non-musicians.

One hundred and two participants were involved in the study, 51 expert musicians and 51 individuals not involved in specific musical learning or practice, matched by gender, age and education. In the musicians group, the time duration from the beginning of musical activities and the kind of specialized activity were also recorded. As measures of perception of kinesthetic images, the *Vividness of Movement Imagery Questionnaire* (VMIQ) was used for the study, along with a performance measure of imagined paths. Results showed that subjective components of imagery, i.e. the visualization involving kinesthetic imagery, discriminate expert musicians from non musicians, and the amount of practice acts as covariate.