

# **I musicisti hanno una migliore memoria a breve termine dei nonmusicisti?**

## **Uno studio multilaboratorio / Do musicians have better short-term memory than nonmusicians? A multi-lab study**

**Massimo Grassi<sup>1</sup> a nome de “The Music Ensemble”**

<sup>1</sup> Dipartimento di Psicologia Generale, Università di Padova, Italia

indirizzo email del primo autore (Corresponding author), es.

[massimo.grassi@unipd.it](mailto:massimo.grassi@unipd.it)

I musicisti sono spesso considerati un esempio positivo di plasticità cerebrale e dei benefici cognitivi associati. Questo emerge quando musicisti esperti (ad esempio, musicisti con oltre dieci anni di formazione e pratica musicale) vengono confrontati con non musicisti. Un risultato comportamentale frequentemente osservato è un vantaggio della memoria a breve termine dei primi rispetto ai secondi. Sebbene le meta-analisi disponibili riportino che la dimensione dell'effetto di questo vantaggio sia media ( $d=0,5$ ), nessuno studio in letteratura era adeguatamente potente per stimare in modo affidabile un effetto di tale dimensione. Questo studio multi-laboratorio è stato ideato, realizzato e condotto da diversi gruppi che hanno lavorato su questo argomento. Il nostro obiettivo era fornire una stima condivisa e affidabile, guidata dalla comunità, del vantaggio di memoria dei musicisti (se presente) e stabilire un metodo e uno standard per futuri studi in neuroscienze e psicologia che confrontino musicisti esperti e non musicisti. Trentatré unità di ricerca hanno reclutato un totale di 598 musicisti esperti e 598 non musicisti, un numero sufficientemente grande per stimare effetti piccoli ( $d=0,3$ ) con un'elevata potenza statistica ( $\beta=0,90$ ). Successivamente, abbiamo misurato la differenza nella memoria a breve termine per stimoli verbali, visuospatiali e musicali. Abbiamo anche esaminato fattori cognitivi, di personalità e socioeconomici che potrebbero mediare la differenza. I musicisti hanno messo in luce una memoria a breve termine largamente migliore rispetto ai non musicisti per stimoli musicali, con una dimensione dell'effetto di  $d=1.1$ . Inoltre, avevano anche un piccolo vantaggio di memoria per stimoli visuospatiali ( $d=0.3$ ) e un vantaggio trascurabile per stimoli verbali ( $d=0.2$ ). Questo lavoro pone le basi per pratiche di ricerca solide negli studi che

confrontano musicisti esperti e non musicisti, e contribuisce al dibattito in corso sui possibili benefici cognitivi della formazione musicale.

## **English**

Musicians are often regarded as a positive example of brain plasticity and associated cognitive benefits. This emerges when expert musicians (e.g., musicians with over ten years of music training and practice) are compared with nonmusicians. A frequently observed behavioral finding is a short-term memory advantage of the former over the latter. Although available meta-analysis reports that the effect size of this advantage is medium ( $d=0.5$ ), no literature study was adequately powered to estimate reliably an effect of such size. This multi-lab study that has been ideated, realised, and conducted by several groups that have been working on this topic. Our ultimate goal was to provide a community-driven shared and reliable estimate of the musicians' memory advantage (if any) and set a method and a standard for future studies in neuroscience and psychology comparing expert musicians and nonmusicians. Thirty-three research units recruited a total of 598 expert musicians and 598 nonmusicians, a number that is sufficiently large to estimate a small effect size ( $d=0.3$ ) with a high statistical power ( $\beta=0.90$ ). Successively, we measured the difference in short-term memory for verbal, visuospatial, and musical stimuli. We also looked at cognitive, personality, and socioeconomic factors that might mediate the difference. Musicians had better short-term memory than nonmusicians for musical stimuli with an effect size of,  $d=1.1$ . They also had a small advantage for visuo-spatial stimuli ( $d=0.3$ ) and a negligible advantage for verbal stimuli ( $d=0.2$ ). This work sets the basis for sound research practices in studies comparing expert musicians and nonmusicians, and contributes to the ongoing debate on the possible cognitive benefits of musical training.

## **Lista completa autori e affiliazioni**

Massimo Grassi<sup>1†</sup>, Francesca Talamini<sup>2†</sup>, Gianmarco Altoè<sup>3</sup>, Elvira Brattico<sup>4,5</sup>, Anne Caclin<sup>6</sup>, Barbara Carretti<sup>1</sup>, Véronique Drai-Zerbib<sup>7</sup>, Laura Ferreri<sup>8,9</sup>, Filippo Gambarota<sup>3</sup>, Jessica Grahn<sup>10</sup>, Lucrezia Guiotto Nai Fovino<sup>1,11</sup>, Marco Roccatò<sup>1</sup>, Antoni Rodriguez-Fornells<sup>12,13</sup>, Hannah Strauss<sup>2</sup>, Swathi Swaminathan<sup>10,10</sup>, Barbara Tillmann<sup>14</sup>, Peter Vuust<sup>4,15</sup>, Jonathan Wilbiks<sup>16</sup>, Marcel Zentner<sup>2</sup>, Eleonora Fullone<sup>8</sup>, Paulina d. C. Martín Sánchez<sup>17</sup>, Rafael Román-Caballero<sup>17,18</sup>, Laurel J. Trainor<sup>18,19</sup>, Anne-Isabelle de Parcevaux<sup>7</sup>, Daniela Sammler<sup>20</sup>,

Antonia Čerič<sup>20</sup>, Stefanie Gloggengießer<sup>20</sup>, Jed Villanueva<sup>21</sup>, Assal Habibi<sup>21</sup>, Oscar Daniel<sup>22</sup>, Aarushi Kalsi<sup>22</sup>, Kelly Jakubowski<sup>22</sup>, Deniz Başkent<sup>23</sup>, Eleanor E. Harding<sup>23</sup>, Paula Roncaglia-Denissen<sup>24</sup>, Victor C. Escribano<sup>25</sup>, Lucia Gonzalez Sanchez<sup>25</sup>, Ana Zappa<sup>25</sup>, Simon P. Limmer<sup>2</sup>, Florian J. Strauch<sup>2</sup>, Jaakko Nokkala<sup>26</sup>, Mari Tervaniemi<sup>27,28</sup>, Veikka P. Holma<sup>29</sup>, Suvi Saarikallio<sup>29,30</sup>, Petri Toiviainen<sup>31,32</sup>, Rosaliina Kelo<sup>26</sup>, Fleur L. Bouwer<sup>33</sup>, Maria G. Jol<sup>33</sup>, Niloufar Najafi<sup>33</sup>, Aïssa M. N. Baldé<sup>34</sup>, Cesar F. Lima<sup>34</sup>, Glenn E. Schellenberg<sup>34,35</sup>, Caitlin Fitzpatrick<sup>10</sup>, Andrew J. Oxenham<sup>36</sup>, Neha Rajappa<sup>36</sup>, Kelly L. Whiteford<sup>36</sup>, Chengran K. Liu<sup>37</sup>, Daniel Mirman<sup>37</sup>, Prof Katie Overy Overy<sup>38,39</sup>, Gangothri S. Ladegam<sup>37</sup>, Jessica P. Michael<sup>37</sup>, Axelle Calcus<sup>40</sup>, Kirsty Hawkins<sup>41</sup>, Daniel Müllensiefen<sup>41</sup>, Léo Dairain<sup>40</sup>, Mathilde Groussard<sup>42</sup>, Herve Platel<sup>42</sup>, Alice Poissonnier<sup>42</sup>, Anna Fiveash<sup>43</sup>, Steffen A. Herff<sup>43</sup>, Farrah Y.-A. Sa'adullah<sup>43</sup>, André Lee<sup>44</sup>, Edoardo Passarotto<sup>45</sup>, Florian Worschech<sup>46</sup>, Delphine Dellacherie<sup>47</sup>, Nzonlang Ndassi<sup>47</sup>, Séverine Samson<sup>47</sup>, Laurel J. Trainor<sup>18,19</sup>, Emily A. Wood<sup>18</sup>, Simone Dalla Bella<sup>48,49</sup>, Fortier Juliette<sup>48</sup>, Plasse Marie-Elisabeth<sup>6</sup>, Souffiane Ragnya-Noraso<sup>6</sup>, Karla Aguilar<sup>16</sup>, Michaela Ritchie<sup>16</sup>, Giulio Carraturo<sup>5</sup>, Christ B. Aryanto<sup>50,51</sup>, Renee Timmers<sup>52</sup>, Claudia C. von Bastian<sup>50</sup>, Veronica Kandro<sup>53</sup>, L. R. Slevc<sup>53</sup>, Nicholas Tantengco<sup>53</sup>, Rachel Thompson<sup>53</sup>, Clara Tuske<sup>53</sup>, Frederico C. Assis Leite<sup>54,55</sup>, Graziela Bortz<sup>56</sup>, Juliana L. d. B. Fialho<sup>57,58</sup>, Maria Gabriela M. Oliveira<sup>59,60</sup>, Italo R. Rodrigues Menezes<sup>60</sup>, Laura Bishop<sup>61,62</sup>, Anne Danielsen<sup>61</sup>, Tor Endestad<sup>63,64</sup>, Heidi M. U. Hansen<sup>63</sup>, Bruno Laeng<sup>63,61</sup>, Nora R. Serres<sup>63,61</sup>, Antonio Criscuolo<sup>65</sup>, Sonja A. Kotz<sup>66,67</sup>, Noah R. Fram<sup>68</sup>, Reyna Gordon<sup>69,70</sup>, Miriam Lense<sup>71</sup>

<sup>1</sup>Department of General Psychology, University of Padua, Italy, <sup>2</sup>Department of Psychology, University of Innsbruck, <sup>3</sup>Department of Developmental Psychology and Socialization, University of Padua, Italy, <sup>4</sup>Center for Music in the Brain (MIB), Department of Clinical Medicine, Aarhus University, Denmark, <sup>5</sup>Department of Education, Psychology, Communication, University of Bari Aldo Moro, Italy, <sup>6</sup>Université Claude Bernard Lyon 1, CNRS, INSERM, Centre de Recherche en Neurosciences de Lyon CRNL U1028 UMR5292, F-69500, Bron, France, <sup>7</sup>LEAD - CNRS UMR5022 - Université Bourgogne Franche-Comté, <sup>8</sup>Department of Brain & Behavioural Science, Università degli Studi di Pavia, <sup>9</sup>Laboratoire d'Etude des Mécanismes Cognitifs, Université Lumière Lyon 2, <sup>10</sup>Department of Psychology, Western University, <sup>11</sup>Brain and Mind Institute, Western University, <sup>12</sup>Institució Catalana de Recerca i Estudis Avançats (ICREA), <sup>13</sup>Dept. of Cognition, Development and Education Psychology, University of Barcelona / IDIBELL, <sup>14</sup>LEAD – CNRS UMR5022, University of Burgundy,

Dijon, France, <sup>15</sup>Royal Academy of Music Aarhus/Aalborg, Denmark, <sup>16</sup>Department of Psychology, University of New Brunswick Saint John, 100 Tucker Park Road, Saint John, NB, CANADA, <sup>17</sup>Mind, Brain and Behavior Research Center (CIMCYC), University of Granada, Granada, Spain, <sup>18</sup>Department of Psychology, Neuroscience & Behaviour, McMaster University, <sup>19</sup>McMaster Institute for Music and the Mind, McMaster University, <sup>20</sup>Research Group Neurocognition of Music and Language, Max Planck Institute for Empirical Aesthetics, Frankfurt/M., Germany, <sup>21</sup>Brain and Creativity Institute, Dornsife College of Letters Arts and Sciences, University of Southern California, <sup>22</sup>Durham University, <sup>23</sup>Department of Otorhinolaryngology / Head and Neck Surgery, University Medical Center Groningen, University of Groningen, The Netherlands, <sup>24</sup>Cognitive Science and Artificial Intelligence Department, Tilburg School of Humanities and Digital Sciences, Tilburg University, <sup>25</sup>University of Barcelona, <sup>26</sup>University of Helsinki, <sup>27</sup>Centre of Excellence in Music, Mind, Body, and Brain; Faculty of Educational Sciences, University of Helsinki, <sup>28</sup>Cognitive Brain Research Unit, Faculty of Medicine, University of Helsinki, <sup>29</sup>Centre of Excellence in Music, Mind, Body, and Brain, University of Jyväskylä, Finland, <sup>30</sup>Centre of Excellence in Music, Mind, Body, and Brain, University of Helsinki, Finland, <sup>31</sup>Centre of Excellence in Music, Mind, Body and Brain, University of Jyväskylä, <sup>32</sup>Department of Music, Art and Culture Studies, University of Jyväskylä, <sup>33</sup>Cognitive Psychology Unit, Institute of Psychology & Leiden Institute for Brain and Cognition, Leiden University, Leiden, Netherlands, <sup>34</sup>Instituto Universitário de Lisboa (ISCTE-IUL), Lisboa, Portugal, <sup>35</sup>University of Toronto Mississauga, <sup>36</sup>Department of Psychology, University of Minnesota, United States, <sup>37</sup>University of Edinburgh, <sup>38</sup>Reid School of Music, ECA, University of Edinburgh, <sup>39</sup>Edinburgh Neuroscience, University of Edinburgh, <sup>40</sup>Université libre de Bruxelles, <sup>41</sup>Goldsmiths, University of London, <sup>42</sup>Inserm, U1077, EPHE, UNICAEN, Normandie Université, PSL Université Paris, CHU de Caen, GIP Cyceron, Neuropsychologie et Imagerie de la Mémoire Humaine (NIMH), 14000 Caen, France, <sup>43</sup>The MARCS Institute for Brain, Behaviour and Development, Western Sydney University, <sup>44</sup>Institute of Music Physiology and Musicians' Medicine, <sup>45</sup>Institute of Music Physiology and Musicians' Medicine Hanover University of Music, Drama, and Media, <sup>46</sup>Institute of Music Physiology and Musicians' Medicine, Neues Haus 1, Hanover, Germany, <sup>47</sup>Université de Lille, ULR 4072 - PSITEC - Psychology: Interactions, Time, Emotions, Cognition, F-59000 Lille, France, <sup>48</sup>International Laboratory for Brain, Music and Sound Research (BRAMS), University of

Montreal, Montreal, Canada, <sup>49</sup>Center for Research on Brain, Language and Music (CRBLM), Montreal, Canada, <sup>50</sup>Department of Psychology, University of Sheffield, <sup>51</sup>Faculty of Psychology, Atma Jaya Catholic University of Indonesia, <sup>52</sup>Department of Music, University of Sheffield, <sup>53</sup>Department of Psychology, University of Maryland, College Park, USA, <sup>54</sup>[UNIFESP] Universidade Federal de São Paulo, <sup>55</sup>[UNESP] Universidade Estadual Paulista Julio de Mesquita Filho, <sup>56</sup>Unesp, <sup>57</sup>Universidade Estadual Paulista “Júlio de Mesquita Filho”, <sup>58</sup>Universidade Cruzeiro do Sul, <sup>59</sup>State University of Sao Paulo - Unesp, <sup>60</sup>Universidade Federal de São Paulo, <sup>61</sup>RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion, University of Oslo, <sup>62</sup>Department of Musicology, University of Oslo, <sup>63</sup>Department of Psychology, Faculty of Social Sciences, University of Oslo, Oslo 0373, Norway, <sup>64</sup>RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion, University of Oslo, Oslo 0373, Norway, <sup>65</sup>Department of Neuropsychology & Psychopharmacology, Faculty of Psychology and Neuroscience, Maastricht University, <sup>66</sup>Maastricht University, <sup>67</sup>Max Planck Institute for Human Cognitive and Brain Sciences, <sup>68</sup>Vanderbilt University Medical Center, <sup>69</sup>Department of Otolaryngology–Head and Neck Surgery, Vanderbilt University Medical Center, Nashville, TN, <sup>70</sup>Vanderbilt Genetics Institute, Vanderbilt University, Nashville, TN, <sup>71</sup>Department of Otolaryngology – Head and Neck Surgery, Vanderbilt University Medical Center, Nashville, TN

†Correspondence should be addressed to Massimo Grassi; E-mail: [massimo.grassi@unipd.it](mailto:massimo.grassi@unipd.it)