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Do musicians have better mnemonic and executive performance than actors? Influence of regular musical or theatre practice in adults and in the elderly.

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1 **Title:**

2 **Do musicians have better mnemonic and executive performance than**
3 **actors? Influence of regular musical or theatre practice in adults and in the**
4 **elderly.**

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27 The aim of the present study was to investigate the cognitive difference between regular
28 artistic practitioners. Several studies have demonstrated the influence of musical practice on
29 cerebral activity and cognition, but comparing this practice to another artistic domain such as
30 theatre had yet to be done. However, both of these artistic activities require many hours of
31 individual or collective practice in order to reach an advanced level. Music and theatre
32 practice require the interaction between higher-order cognitive functions and several sensory
33 modalities (auditory, verbal, visual and motor), as well as the regular learning of new pieces.
34 Our results are consistent with previous works suggesting that adult musicians outperformed
35 control subjects in standardized cognitive tasks, but a lifespan approach was never adopted in
36 previous studies. Additionally, it highlights for the first time that both musical and theatrical
37 expertise may involve specific cognitive differences across the lifespan. Furthermore, we
38 observed domain-specific cognitive patterns: musical practice was associated with better
39 executive functions and working memory, and theatrical expertise with better long-term
40 verbal memory and verbal fluency.

41
42 **Keywords:** Music; Theatre; Practice; Cognition; Aging; Lifespan

43 **Abstract**

44

45 The effects of musical practice on cognition are well established yet rarely compared with
46 other kinds of artistic training or expertise. This study aims to compare the possible effect of
47 musical and theatre regular practice on cognition across the lifespan. Both of these artistic
48 activities require many hours of individual or collective training in order to reach an advanced
49 level. This process requires the interaction between higher-order cognitive functions and
50 several sensory modalities (auditory, verbal, visual and motor), as well as regular learning of
51 new pieces. This study included participants with musical or theatre training, and healthy
52 controls matched for age (18 to 84 years old) and education. The objective was to determine
53 whether specific expertise in these activities had an effect on cognition across the lifespan,
54 and a protective influence against undesirable cognitive outcomes associated with aging. All
55 participants underwent a battery of cognitive tasks that evaluated processing speed, executive
56 function, fluency, working memory, verbal and visual long-term memories, and non-verbal
57 reasoning abilities. Results showed that music and theatre artistic practices were strongly
58 associated with cognitive enhancements. Participants with musical training were better in
59 executive functioning, working memory and non-verbal reasoning, whereas participants with
60 regular acting practice had better long-term verbal memory and fluency performance. Thus,
61 taken together, results suggest a differential effect of these artistic practices on cognition
62 across the lifespan. Advanced age did not seem to reduce the benefit, so future studies should
63 focus on the hypothetical protective effects of artistic practice against cognitive decline.

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68 INTRODUCTION

69
70 Without a doubt, musical practice has become a model for the study of neuroplasticity
71 in cognitive neuroscience over the past twenty years (Altenmüller, 2008; Schlaug 2015). It is
72 now accepted that musical expertise leads to cerebral reorganizations resulting in changes in
73 the brain anatomy of regions engaged during formal music learning, such as motor (Wan &
74 Schlaug, 2010), auditory perception (Parbery-Clark et al., 2013; Bidelman et al., 2015; Zendel
75 et al., 2019) and memory areas (Groussard et al., 2010, 2014; Fauvel et al. 2014). Musical
76 practice also influences cognitive functioning, involving better performance on tasks that
77 directly call upon skills explicitly learned during formal music learning (*near transfers*) but
78 also with an effect on general cognitive functions (*far transfers*) in musicians (Schellenberg &
79 Weiss 2013, Fauvel et al., 2013, Schlaug 2015). Studies reported better performance for
80 musicians compared to non-musicians mainly in executive functioning, notably working
81 memory, flexibility and verbal fluency (Degé, Kubicek and Schwarzer, 2011; Criscuolo et al.
82 2019).

83 Some authors suggested that beyond musical practice, an active, socially engaged,
84 mentally and physically stimulating lifestyle can also have a positive effect on cognitive
85 functioning (Jung et al. 2017). Brain activity and structure are shaped by experience
86 throughout the lifespan, even at an old age. This plasticity has often been demonstrated after
87 long and intensive trainings, where performance in trained activity improves after practice and
88 leads to the building of a cognitive reserve that could explain the interindividual variability
89 regarding aging (Stern, 2009; Chan et al. 2018). This suggests that higher cognitive reserve is
90 associated with compensatory adjustment and could slow down age-related cognitive decline
91 (Hinault and Lemaire, 2020; Kalpouzos et al. 2008). Different factors influence the variability
92 of this reserve among subjects, including levels of education and general lifestyle (diet and
93 physical fitness), but also the quality of social interaction and hobbies (Scarmeas & Stern
94 2003).

95 Like music, theatrical practice is an artistic activity that requires many hours of
96 individual or collective training in order to reach an advanced level. This process requires the
97 interaction between higher-order cognitive functions and several sensory-cognitive modalities
98 (auditory, verbal, visual and motor), as well as the regular learning of new pieces (for
99 musicians see Brown et al. 2015). However, only few studies have investigated the positive
100 effect of artistic activities other than music, such as theatre, on cognition in adulthood. While
101 theatrical practice also seems to have potential effect on overall well-being and cognition, its
102 effect on cognitive functions is still poorly understood. To our knowledge, only Noice's team
103 has conducted a series of studies to specify the effect of theatrical practice on cognitive
104 processes. These studies investigated cognitive changes following short-term theatrical
105 interventions in older adults (Noice & Noice 1999, Noice et al. 2004, Banducci et al. 2017,
106 Noice et al. 2014 for review). They compared older participants who received theatre arts
107 training (n=44), visual arts training (n=44) or no-treatment (controls, n=36) during nine 90-
108 minute sessions over a month. The pretest and posttest comparison suggested that the
109 performance of the theatre arts intervention group was better than no-intervention group on
110 word recall, listening span and problem-solving tasks. Compared to the visual arts group, the
111 theatre arts group performed better on problem solving only (Noice et al. 2004). Recent work
112 from this team further expands these results, as Banducci et al. (2017) compared the cognitive
113 benefit of an active acting program including 86 healthy aging versus 93 participants
114 constituting the control group (history of art classroom) for 4 weeks. A cognitive battery was
115 administered before and after intervention, and again in a 4-month follow-up. The participants
116 of the active acting program benefited most relative to the control group in episodic recall

117 only, with gains still evident up to 4 months after intervention. Both groups were similar in
118 the magnitude of gains in working memory, executive function and processing speed. Due to
119 the scarcity of work on theatre practice compared to music training in the literature, it seems
120 necessary to specify the benefits of theatrical regular practice on cognition and to better
121 understand its effect throughout life. Many factors appear to influence an individual's aging
122 trajectory (Hinault & Lemaire, 2020; Raz and Kennedy, 2009), suggesting that interventions
123 could possibly slow down cognitive decline and promote healthy aging. To this end, various
124 behavioral interventions have been proposed, such as physical activity and cognitive training
125 (Colcombe and Kramer, 2003; Jaeggi et al., 2008; Karbach and Kray, 2009, Fauvel et al.,
126 2013; Sprague et al. 2019 for reviews), and the benefits of arts practices for promoting health
127 have received growing interest. Importantly, while prior studies have undoubtedly shown the
128 association between arts engagement and well-being (Mella et al. 2017 ; Fancourt and Stepoe
129 2019), objective measurement of the specific cognitive benefit associated with repeated and
130 regular art practices like acting or music across the lifespan, have not been carried out to the
131 best of our knowledge.

132 The literature is consistent with results obtained by the first study performed on the
133 link between the practice of a musical instrument and cognitive functions in elderly subjects
134 (Hanna-Pladdy & MacKay 2011). These authors observed that elderly musicians
135 outperformed elderly non-musicians on nonverbal working memory, naming and executive
136 function tests. Moreover, their study suggested a correlation between musicians considered to
137 have a high level of expertise (i.e. having at least more than 10 years of practice) and the
138 preservation of cognitive functioning while aging. Contrarily, Mansen et al. 2017 showed that
139 the time spent making music was not the most important criterion with respect to cognitive
140 function compared with other practice characteristics such as current amount of time making
141 music or age of onset of musical practice.

142 To our knowledge, no study has been carried out among people engaged in theatre
143 practice in order to evaluate their cognitive abilities and possible reserve effects. However, it
144 seems logical to think that many years of theatre practice could influence cognition and
145 especially memory, as actors have to memorize new texts regularly. Similarly, it seems
146 surprising that actors have never constituted a reference group or a comparison group with
147 musicians. This is probably due to the fact that it is more difficult to define equivalent criteria
148 for the level of expertise for actors whose training and practices are more heterogeneous than
149 for musicians educated in music conservatories.

150 The main objective of this study was to compare the positive influence of musical and
151 theatrical current and regular practice on cognition. Our goal was first to determine,
152 throughout the lifespan, whether people with current musical and theatrical practice could
153 show cognitive differences, and if the number of years of practice influence these
154 modifications. Second, we aimed to study the effect of musical and theatrical practice on
155 cognition in older adults, in order to assess the specific differences in cognition between
156 actors and musicians while aging (e.g. executives and episodic memory processes).

157 Participants underwent a battery of cognitive tasks evaluating processing speed,
158 executive functioning, fluency, working memory, verbal and visual long-term memories, and
159 non-verbal reasoning abilities. Considering the literature, the main expectation was that both
160 groups (musicians and actors) would perform higher than control subjects without any
161 intensive and regular leisure activity on tasks evaluating both executive functions and
162 memory. We also expected a specific effect of the type of practice on cognition, with better
163 performance for verbal memory in actors and executive functioning and reasoning in
164 musicians. Moreover, we expected that processes involved in reading scores in musicians

165 would increase their abilities in visuo-spatial memory. We finally expected that these patterns
 166 would be maintained in older adults.

167

168 **MATERIALS AND METHODS**

169

170 **Participants**

171 We recruited three groups of healthy subjects differing only in regular and sustained
 172 practice of a specific leisure activity (music; theatre, no specific practice for the control
 173 group). The dataset was obtained from 146 participants, 50 controls; 50 “musicians” and 46
 174 “actors” matched for age and education. Three participants (1 by group) were excluded
 175 because they only partially completed the neuropsychological assessment (Table 1). All
 176 participants were native French speakers, with normal hearing and normal or corrected to
 177 normal vision without any reported neurological or psychiatric conditions, as assessed by a
 178 medical interview. None of them presented signs of cognitive impairment (i.e. two or more
 179 scores in two or more cognitive domains below two standard deviations of the norms for their
 180 age class). All participants provided informed consent before being tested and all procedures
 181 were conducted in agreement with the ethical principles of Declaration of Helsinki.

182

183 **Table 1 : Demographic data of participants and practice background information for Musicians and Actors.**

	Controls	Musicians	Actors	Stats	p-value
N of subjects	49	49	45		
Gender	30F +20 M	24F + 26 M	30F + 16 M	$X^2=3.096$	0.213
Age	47.47 ± 17.78 [18-80]	47.84 ± 18.3 [20-83]	41.58 ± 18.13 [18-84]	F= 1.748	0.178
Years of education	13.9 ± 2.946 [9-20]	14.73 ± 2.139 [9-19]	13.89 ± 2.648 [7-20]	F= 1.689	0.188
Age onset of practice	n.a	13.02 ± 12.82 [2-65]	24.9 ± 15.34 [4-70]	U MW= 506	<.001
Years of practice	n.a	31.51 ± 16.67 [5-65]	17.13 ± 10.82 [4-45]	U MW=539.5	<.001
Weekly practice hours	n.a	13.03 ± 11.03 [1-49]	10.18 ± 9.83 [2-40]	U MW=1.318	0.191
Number of exhibition /year	n.a	18.14 ± 24.84 [0-100]	14.43 ± 22.14 [0-100]	U MW=0.76	0.448

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186 Controls were defined as participants who had practiced any leisure activity regularly
 187 (more than 4 hours/week) associated with formal lessons (physical activity or drawing lesson
 188 for examples) and had never taken any formal music or acting lessons, that could neither play
 189 nor read music.

190 Participants were included in “Musicians” group when they reported current and
 191 regular practice at the moment of the study for more than 3 years of musical instrument
 192 without interruption, more than 4 hours/week, and if they had received formal music training.
 193 In addition to this, Musicians had to never have practiced theatre. Musicians were recruited
 194 from several French conservatories or music schools (no self-educated musicians were
 195 included). They played various musical instruments (piano, guitar, trumpet, etc.). To study the
 196 influence of instrumental practice and avoid confounding effect between singing and
 197 instrumental practices (e.g. Mansens et al. 2017) we excluded participants who previously
 198 performed choral singing in all groups.

199 Participants were included in “Actors” group when they reported current and regular
 200 acting practice at the moment of the study for more than 3 years without interruption, more

201 than 4 hours/week, and if they had taken formal theatre lessons. In addition to this, Actors
 202 must had never practiced a musical instrument. All Actors were recruited from theatre
 203 companies or cultural associations which offered acting lessons. Without being professional,
 204 they learned new texts on a regular basis and had regular live performances (two per month in
 205 average).

206 Musicians' and Actors' background information is provided in Table 1, which
 207 includes the age onset of practice, number of years of practice, weekly practice hours, number
 208 of exhibitions by year.

209 We then reduced our sample to individuals who were 50 years and older to study the
 210 difference in cognition between older practitioners (Schneider et al. 2019). This sample was
 211 composed of 27 Controls, 24 Musicians and 15 Actors (see tables 2).
 212

213 **Table 2 : Demographic data of participants of 50 years and older Practice background information for Musicians and**
 214 **Actors of 50 years and older**

	Controls	Musicians	Actors	Stats	p-value
N of subjects	27	24	15		
Gender	18F + 9 M	12F + 12 M	9F + 6 M	$\chi^2 = 1.47$	0.48
Age	61.1 ± 7.29 [51-80]	63.9 ± 8.81 [50-83]	62.6 ± 9.73 [52-84]	F= 0.723	0.489
Years of education	14.5 ± 2.65 [9-19]	14.2 ± 1.99 [9-17]	12.9 ± 2.45 [10-20]	F= 2.31	0.108
Age onset of practice	n.a	18.5 ± 16.6 [2-65]	37.4 ± 17 [12-70]	U MW= 69.5	<.001
Years of practice	n.a	43 ± 15 [12-65]	23.7 ± 13.4 [4-45]	U MW=60.5	<.001
Weekly practice hours	n.a	12.8 ± 11.00 [3.5-49]	10.5 ± 11.8 [3-40]	U MW=130	0.152
Number of exhibition /year	n.a	14.3 ± 18.6 [0-60]	15.9 ± 20.4 [2-80]	U MW=142	0.27

215

216

217 **Cognitive functioning**

218 Cognitive functioning was measured using several assessments covering various
 219 cognitive domains (Table 3) that are clearly impacted by normal aging (Salthouse, 2010;
 220 Hedden and Gabrieli, 2004), the earliest and most concerned being processing speed, working
 221 memory (maintenance and manipulation of information during a short period of time), spatial
 222 ability, reasoning, and episodic memory (declarative long-term contextual remembering of
 223 personal events or information). The entire test battery was administered in a single session,
 224 which lasted about 90 min, and took place in a quiet room.
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Table 3 : Description of the tests and the dependent variables used in the study

Cognitive functions assessed	Psychometric tests	Dependent variables (outcomes)
Long-term verbal memory	BEM-144's 12 words (Signoret, 1991)	Total score of the three trials in learning phase (BEM Total) Number of word recalled in the delayed recall (BEM Recall)
	Doors test (Baddeley et al. 1994)	Number of doors recognized (Doors Total)
Long-term visual memory	Rey-Osterrieth complex figure (Rey, 1959)	Score of redraw fidelity (number of details, their completeness and location) (Rey Recall)
	Forward digit span (Godefroy et al. 2008)	Highest number of digits properly recalled in 2/3 trials (Digit Span)
Working memory	Forward digit span (Godefroy et al. 2008)	Total number of target symbols correctly identified (GZ-f)
Attentional abilities	d2 Test (Brickenkamp, 1981)	Total number of words in 2 min (Phonemic Fluency)
	Phonemic Fluency task (Cardebat et al. 1990)	Total number of words in 2 min (Semantic Fluency)
Executive control and verbal abilities	Semantic Fluency task (Cardebat et al. 1990)	Number of items processed (GZ)
	d2 Test (Brickenkamp, 1981)	Number of correct associations in 2 minutes (Codes)
Processing speed	Digit-symbol coding subtest (Wechsler, 2000)	Number of matrices properly completed (Matrix)
	Matrix Reasoning subtests (Wechsler, 2000)	
Non-verbal reasoning	Matrix Reasoning subtests (Wechsler, 2000)	

235

236 *Long-term Memory:*

237 Long-term verbal memory was measured using the 12-word subtest from the Signoret
238 BEM-144 (Signoret 1991). This verbal memory test consists of learning 12 words during 3
239 sessions. After every trial, participants are asked to recall as many words as possible. Then
240 participants are distracted by performing a non-verbal task for approximately 7 min. After
241 that, they are asked to recall as many words as possible. We used two scores on the 12-word
242 BEM test: the total score of the three trials to evaluate total learning (BEM Total), and the
243 number of words recalled during the delayed recall (BEM Recall) to assess episodic memory.

244 Long-term visual memory was evaluated using the Baddeley's Doors test (Baddeley et
245 al. 1994). This test is a nonverbal recognition test based on colored photographs of doors
246 composed of two parts (A and B). For each part, 12 doors are shown individually for 3
247 seconds. Then, the participants are asked to pick out the one out of the four that had been
248 shown before. The score is the number of correct answers of the two parts combined (Doors
249 Total).

250 The Rey-Osterrieth complex figure (Rey, 1959) was administered and consists of
251 redrawing an abstract geometrical shape from memory that had been copied 3 minutes earlier
252 (Rey Recall). The maximum final score is 36. This test is classically used for evaluating of
253 visuospatial constructional ability and visual episodic memory.

254

255 *Executive Functioning*

256 The phonological loop of the working memory, which is the ability to retain verbal
257 information for a short time by mean of mental repetition (Baddeley, 2003; Baddeley et al.,
258 1998), was evaluated using the forward digit span (Godefroy et al 2008). Participants had to
259 immediately recall series of digits in the order they were presented. The score recorded was
260 the size of the forward digit span with 2 successive correct recalls (Digit Span).

261 We evaluated visual attention using the d2 Test. This test consists of a paper with 14
262 rows of 47 interspersed "p" and "d" characters. The participant had to cross out as many "d"
263 with two marks above or below them as possible, in any order (target symbols), and had to
264 jump to the next rows every 15 s. The target symbols are relatively similar to the distractors (a

265 “p” with two marks or a “d” with one or three marks). In this study, we used the overall
266 performance score (GZ-f) corresponding to the total number of target symbols correctly
267 identified (Brickenkamp, 1981).

268 The phonemic fluency task (Cardebat *et al.* 1990) was used to measure executive
269 functioning. The participant had to name as many words starting with the letter R as possible
270 in two minutes. The score used is the total number of words in two minutes. The semantic
271 fluency was also proposed, in which participants had to name as many fruits as possible in
272 two minutes. Language processing and semantic memory are most the critical components for
273 this task. .

274 Processing speed was measured using the digit-symbol coding subtest from the
275 Weschler Adult Intelligence Scale (WAIS-III, Weschler, 2000). In this task, each digit (from
276 1 to 9) was combined with a specific symbol (example 1/- and 9/=) in the upper row.
277 Participants then had 2 minutes to complete the number maximum of symbols corresponding
278 to the digits presented in the lower rows. The score was the number of correct associations
279 performed in 2 minutes (Codes). We also used the number of items processed (Gz) in the d2
280 test (Brickenkamp, 1981) to evaluate the processing speed.

281

282 ***Reasoning***

283 We administered the Matrix Reasoning subtests of the WAIS-III (Wechsler, 2000) to
284 estimate participants’ non-verbal reasoning skills. In this test, participants were presented
285 with an unfinished matrix of drawings, and had to choose the drawing that logically
286 completed the matrix. This task is classically associated with fluid intelligence (Matrix)
287 (Carpenter, Just and Shell 1990). We used the number of matrices properly completed as a
288 performance score.

289

290 **Procedure and Statistical Analysis**

291 To compare all cognitive variables with each other, scores were standardized. Thus,
292 we transformed all neuropsychological measures into z-scores using the mean and standard
293 deviation of the control groups (n=49) as the reference population for each measure due to the
294 lack or poor reliability of French published norms for some assessments. Thus, all variables
295 were on the same scale, with a mean of 0 and a standard deviation of 1 based on the control
296 group. The higher the z-score, the better the performance. This allowed comparing every
297 performance on the same normalized scale.

298 In order to test for group difference among cognitive tests, we performed multivariate
299 analyses of covariance (MANCOVA), with type of practice (Controls; Musicians; Actors) as
300 between-subjects factor, the cognitive test scores (BEM Total, BEM Recall, Doors Total,
301 Rey Recall, Digit Span, Matrix, Codes, d2 GZ, d2 GZ-f, Phonemic Fluency, Semantic
302 Fluency) as dependent variables and age as confounding variable. As we included more than
303 two dependent variables and because they are intercorrelated, we opted for a MANCOVA.
304 This statistical analysis accounts for the relationship between dependent variables (Warne,
305 2014). To complete the multivariate analyses and examine group differences for each
306 cognitive variable, univariate analyses were performed. A family-wise Bonferroni’s
307 correction for multiple comparison analyses was carried out 2-by-2 for every significant test.

308 To further our exploration of the relationship between musical or theatrical practice
309 and cognitive abilities, we performed a second multivariate analysis on cognitive variables
310 restricted to Musicians and Actors and including Age and Years of practice as variables.

311 In a separate analysis, the same procedure was implemented reducing the sample to
312 people who were 50 years and older to study the effect of expertise on cognition in older
313 adults.

314 The sample size was based on a power analysis, conducted in G*Power 3.1. Regarding
 315 behavioral interactions between age and cognition, assuming an effect size of Cohen’s $f=0.65$
 316 (derived from Carey et al., 2019), an alpha of .05, and three groups, we determined that a total
 317 sample size of at least 15 individuals per study would provide 95% power to detect the
 318 effects.

319 All the statistical analyses were performed with STATISTICA software. The partial
 320 Eta square (η^2_p) was utilized to estimate effect size. Results were considered significant at
 321 $p<.05$.

322

323 **RESULTS**

324 *Effect of expertise on cognitive variables in adults*

325 Results from the multivariate tests on the associations between groups of practice
 326 (Controls; Musicians; Actors) and cognitive tests adjusted for age exhibited a significant
 327 group effect: Wilks’s Lambda [$F_{(22,258)}=3,005, p=0.000015 \eta^2_{partial}=0.204$]. Results showed a
 328 significant effect of groups of practice with higher values for Musicians relative to Controls
 329 for Rey Recall ($p=0.024$); Codes ($p=0.002$); d2 GZ ($p=0.023$); d2 GZ-f ($p=0.023$);
 330 Phonemic Fluency ($p=0.002$), Semantic Fluency ($p=0.019$);relative to Actors for Matrix
 331 ($p=0.006$); and compared to both Controls and Actors for Span (*respectively* $p=0.0002$;
 332 $p=0.008$), . Results also highlighted significantly higher values for Actors than Controls for
 333 BEM Total ($p=0.002$), and Phonemic Fluency ($p=0.009$), and compared to both Controls and
 334 Musicians for BEM Recall (*respectively* $p=0.001$; $p=0,033$)(Table 4, Figure 1).

335 The multivariate analysis exhibited an effect of the Age: Wilks’s Lambda
 336 [$F_{(11,129)}=5.286, p=0.000001$], and univariate analyses suggested a significant effect of the Age
 337 on BEM Total [$F_{(1,139)}=12.49, p=0.0005$], BEM Recall [$F_{(1,139)}=11.32, p=0.001$], Rey Recall
 338 [$F_{(1,139)}=12.319, p=0.0006$], Matrix [$F_{(1,139)}=13.85, p=0.0003$], Codes [$F_{(1,139)}=38.56,$
 339 $p<0.001$], d2 GZ [$F_{(1,139)}=17.85, p=0.0004$], and d2 GZ-f [$F_{(1,139)}=20.77, p=0.0001$].

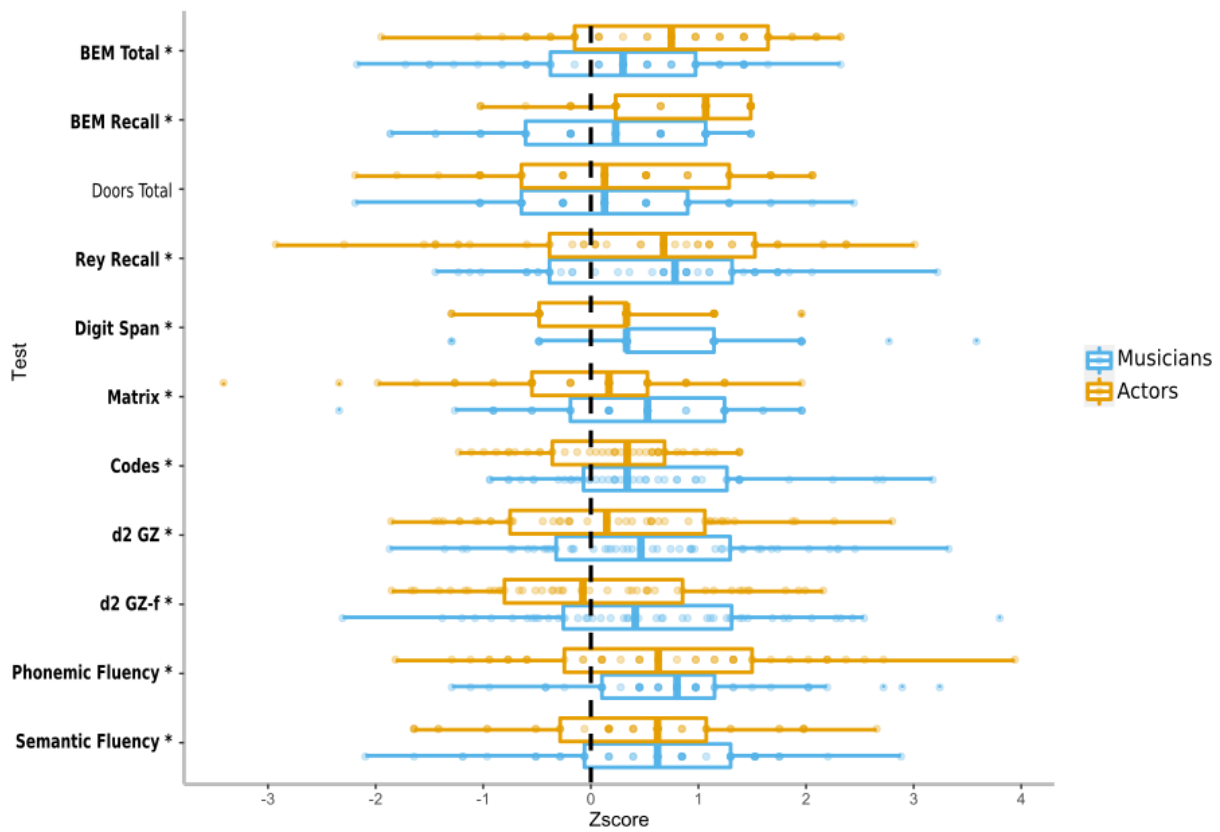
340

341 **Table 4 : Statistical results of MANCOVA for each cognitive variable. SD= Standard Deviation**

	Controls	Musicians	Actors	Statistics		
	Mean±SD	Mean±SD	Mean±SD	F	p-value	Post-hoc
BEM Total	25.673 ± 4.451	26.857 ± 4.21	28.778 ± 4.617	4.450	0.0134	Actors > Controls
BEM Recall	8.449 ± 2.39	8.939 ± 2.277	10.067 ± 1.876	5.256	0.006	Actors > Controls Actors > Musicians
Doors Total	17.673 ± 2.593	18.082 ± 2.448	18.40 ± 2.934	0.632	0.533	
Rey Recall	20.806 ± 4.716	23.592 ± 4.745	23.067 ± 6.463	3.763	0.026	Musicians > Controls
Digit Span	5.592 ± 1.29	6.551 ± 1.174	5.822 ± 0.960	9.449	0.0001	Musicians > Controls Musicians > Actors
Matrix	20.531 ± 2.792	21.735 ± 2.564	20.289 ± 2.928	5.328	0.006	Musicians > Actors
Codes	69.184 ± 17.257	78.776 ± 16.37	73.222 ± 12.269	6.906	0.001	Musicians > Controls
d2 GZ	391.306 ± 72.378	431.327 ± 80.379	401.556 ± 79.371	4.729	0.010	Musicians > Controls
d2 GZ-f	376.878± 65.827	413.551 ± 77.785	382.422 ± 71.237	5.285	0.006	Musicians > Controls
Phonemic Fluency	21.408 ± 5.733	25.755 ± 5.445	25.20 ± 7.191	7.619	0.0007	Musicians > Controls Actors > Controls
Semantic Fluency	21.265 ± 4.420	23.796 ± 4.509	23 ± 4.661	3.937	0.022	Musicians > Controls

342

Z-scores for each cognitive variable studied



343

344 **Figure 1 : median, 1st and 3rd quartiles, min and max z-scores for each cognitive variable studied.**
 345 **Mean and standard deviation of the control group (n=49) serves as reference population for each**
 346 **measure, as such variables were on the same scale with 0 as the mean and 1 as the standard**
 347 **deviation of the control group. The higher the z-score, the better the performance. (*) after a test**
 348 **name indicates a significative difference between Controls and Musicians or Actors.**

349

350 *Effect of years of practice on cognitive variable of adult Musicians and Actors:*

351 The multivariate analysis exhibited a significant effect of groups of practice, Wilks's
 352 Lambda [$F_{(11,80)}=4,058, p=0.0001 \eta^2_{partial}=0.358$], a significant effect of Age, Wilks's Lambda
 353 [$F_{(11,80)}=2,957, p=0.0025 \eta^2_{partial}=0.289$] and no effect of Years of practice on cognitive
 354 variables Wilks's Lambda [$F_{(11,80)}=1,776, p=0.072 \eta^2_{partial}=0.196$]. The univariate analyses on
 355 groups of practice confirmed the higher values for Actors relative to Musicians after
 356 controlling of Age and Years of practice for BEM Total ($p=0.039$) and BEM Recall
 357 ($p=0.0046$) and higher values for Musicians relative to Actors for Span ($p=0.0023$), Matrix
 358 ($p=0,022$), Codes ($p=0,0109$), d2 GZ ($p=0,0404$) and d2 GZ-f ($p=0,0164$).

359

360 *Effects of expertise on cognitive variables in older adults*

361 In a separate analysis, we reduced our sample to participant who were 50 years and
 362 older to study the effects of expertise on cognitive aging. Results from the multivariate tests
 363 that studied the associations between groups of practice (Controls; Musicians; Actors) and the
 364 cognitive tests adjusted for Age exhibited a significant group effect: Wilks's Lambda

365 [$F_{(22,104)}=1.732$, $p=0.0347$ $\eta^2_{partial}=0.268$]. Results of univariate tests showed a significant
 366 effect on groups of practice, with significantly higher values in Musicians relative to Controls
 367 for Rey Recall ($p=0.025$), Digit Span ($p=0.018$), Codes ($p=0.026$) and Semantic Fluency
 368 ($p=0.005$). No significantly higher values in Actors relative to Controls and difference
 369 between Actors and Musicians (Table 5, Figure 2). The multivariate an effect of age, Wilks's
 370 Lambda [$F_{(11,52)}=2.869$ $p=0.005$, $\eta^2=0.378$] and univariate analyses suggested a significant
 371 effect of age on Doors [$F_{(1,62)}=12.82$ $p=0.0007$], Matrix [$F_{(1,62)}=5.216$ $p=0.026$], Codes
 372 [$F_{(1,62)}=14.45$ $p=0.0003$], Phonemic Fluency [$F_{(1,62)}=4.614$ $p=0.036$].

373
 374

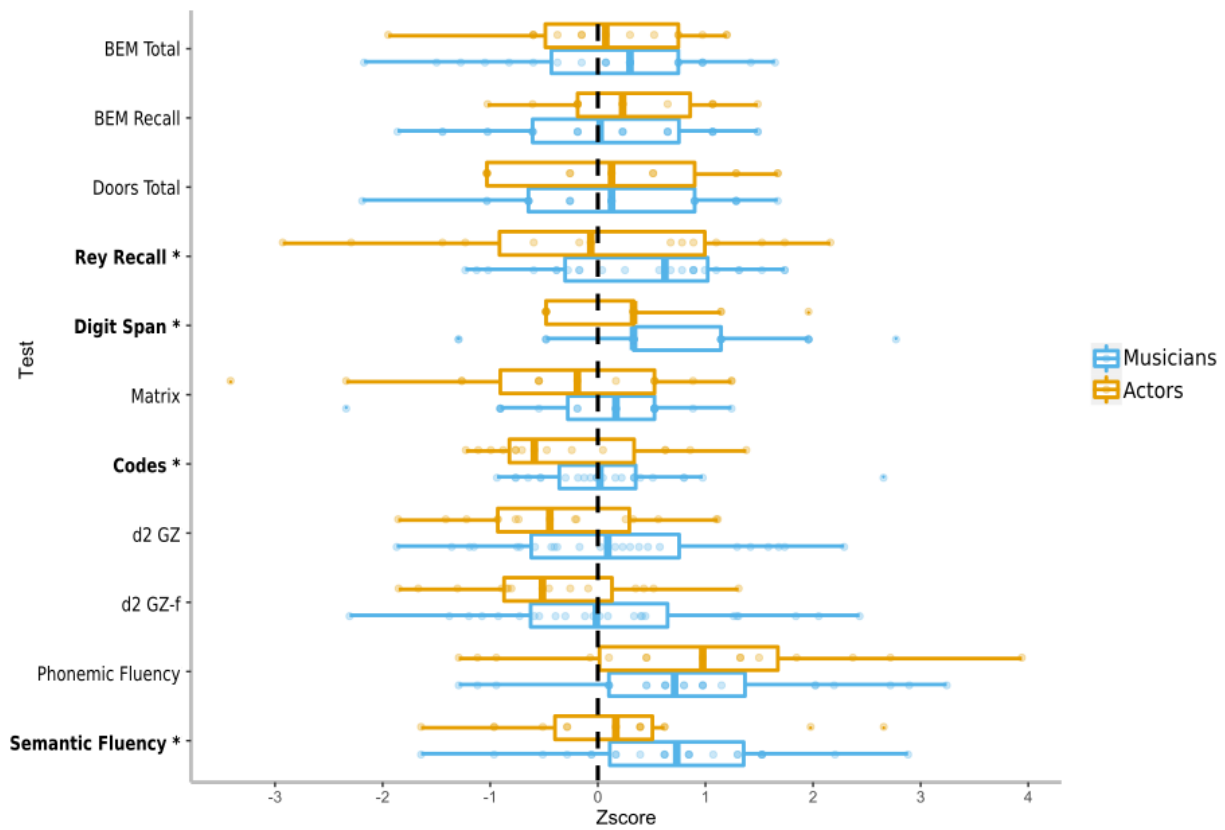
Table 5 : Statistical results of MANCOVA limited to older adults. SD= Standard Deviation

	Controls	Musicians	Actors	Statistics		
	Mean±SD	Mean±SD	Mean±SD	F	p-value	Post-hoc
BEM Total	24.8 ± 4.03	26 ± 4.20	26.1 ± 3.81	1.039	0.359	
BEM Recall	8 ± 2.43	8.46 ± 2.32	9 ± 1.69	1.065	0.351	
Doors Total	17.6 ± 2.61	18 ± 2.51	17.9 ± 3.66	0.62	0.541	
Rey Recall	18.8 ± 4.51	22.6 ± 4.26	20.8 ± 7.01	4.413	0.016	Musicians > Controls
Digit Span	5.44 ± 1.19	6.38 ± 1.28	5.87 ± 0.915	4.428	0.016	Musicians > Controls
Matrix	19.6 ± 2.49	20.6 ± 2.18	19.6 ± 3.68	1.541	1.756	
Codes	61.3 ± 15.30	71.1 ± 13	64.3 ± 13.9	5.367	0.007	Musicians > Controls
d2 GZ	380 ± 59.60	401 ± 79.5	366 ± 64.5	1.632	0.204	
d2 GZ-f	365 ± 50.70	383 ± 76.5	347 ± 56.8	1.884	0.161	
Phonemic Fluency	22.6 ± 6.23	26.3 ± 6.81	26.6 ± 8.48	3.261	0.045	
Semantic Fluency	20.1 ± 4.67	24.3 ± 4.44	22.1 ± 4.83	5.754	0.005	Musicians > Controls

375

376

Z-scores for each cognitive variable studied in older participants



377

378

379 **Figure 2 : median, 1st and 3rd quartiles, min and max z-scores of the older participants for each**
 380 **cognitive variable studied. Mean and standard deviation of the control group (n=49) serves as**
 381 **reference population for each measure, as such variables were on the same scale with 0 as the**
 382 **mean and 1 as the standard deviation of the control group. The higher the z-score, the better the**
 383 **performance. (*) after a test name indicates a significant difference between Controls**
 384 **and Musicians or Actors**

385

386

387 *Effect of years of practice on cognitive variables of older Musicians and Actors*

388

389 The multivariate analysis exhibited only a significant effect of Age, Wilks's Lambda
 390 [$F_{(11,25)}=2,675, p=0.020 \eta^2_{partial}=0.541$]. No effect of Years of practice on cognitive variables
 391 Wilks's Lambda [$F_{(11,25)}=1.396, p=0.235 \eta^2_{partial}=0.381$] and Groups of practice were
 392 observed, Wilks's Lambda [$F_{(11,25)}=0.614, p=0.219 \eta^2_{partial}=0.387$].

393

394 DISCUSSION

395 The aim of the present study was to investigate possible differences in cognition
 396 between different art practitioners ((Musicians and Actors), and also people without artistic
 397 training. Several studies have demonstrated the benefits of musical practice on cerebral

398 activity and cognition, but comparing this practice to another artistic practice such as theatre
399 had yet to be done. Our results are consistent with previous works suggesting that adult
400 musicians outperformed control subjects in standardized cognitive tasks (Fauvel et al. 2013;
401 Schlaug 2015; Sutcliffe et al. 2020) but a lifespan approach was never adopted in anterior
402 studies. In fact, previous work has focused on younger musicians or older musicians whereas
403 our sample had a very wide age range (from 18 to 84 years), allowing us to study
404 practitioners’ cognitive differences throughout the lifespan. We observed a superiority of
405 musicians in long-term visual-spatial memory, working memory, processing speed, executive
406 functioning and non-verbal reasoning. Nevertheless, Musicians did not seem to outperform
407 Controls on verbal episodic memory and visual memory. This result appears consistent with
408 result of a meta-analysis performed by Talamini et al. (2017) on memory. In fact, these
409 authors suggested a small effect size for long-term memory and a possible domain-specific
410 stimuli effect in favor of musical stimuli (Talamini et al. 2017).

411 Nevertheless, we also found a difference in the theatre group on cognition across the
412 lifespan. In line with results of Noice et al. (2004) obtained after a 4-month theatrical
413 intervention, we observed a better long-term verbal memory and verbal fluency in these
414 subjects, compared to controls and musicians. Our results were observed in a large sample of
415 younger to older adults that presented a sustainable practice and intense training. Actors’
416 better performance in verbal episodic memory is consistent with the abilities developed by
417 them while learning a text and retrieving it during performance. In fact, most actors use
418 mnemotechnical strategies to encode and retrieve their scripts (Banducci et al 2017, Noice et
419 al. 2004). Strategies were indeed found to improve memory in both young and older adults
420 (e.g., Hinault et al., 2017a, 2017b). However, Actors did not show a difference on executive
421 functioning, working memory and non-verbal reasoning when compared to Control
422 participants. Thus, in future studies it would seem relevant to consider a more detailed
423 evaluation cognition (including strategy use) in order to confirm whether these effects are
424 limited to verbal and memory aspects and do not influence executive processes, or whether
425 self-monitoring abilities are required in theatre practice (Nettle 2006).

426 This work is the first to statistically compare these two artistic practices, with the same
427 cognitive assessment battery. It highlights for the first time that both musical and theatrical
428 practices could lead to differences in cognition across the lifespan, confirming previous
429 studies on leisure activities, lifestyle and cognition (Hertzog et al. 2008; Reuter-Lorenz &
430 Park 2014). Furthermore, we observed domain-specific differences, musical practice being
431 associated with better executive functions and reasoning, and theatrical practice with better
432 long-term verbal memory. In fact, Musicians had better performance when compared with
433 Actors on working memory, processing speed, executive functioning, and non-verbal
434 reasoning whereas Actors outperformed Musicians for long-term verbal memory.

435 In older adults, this pattern seems to be confirmed for musicians, with higher
436 performances on long-term visual-spatial memory, working memory, processing speed and
437 verbal fluency (Hanna-Pladdy and MacKay 2011; Hanna-Pladdy & Gajewski 2012; Amer et
438 al. 2013; Fauvel et al. 2014; Mansens et al. 2018; Ferreri et al. 2019; Criscuolo et al. 2019).
439 The EEG study of Moussard *et al.* (2016) on elderly musicians (currently practicing about 11
440 hours/week) and non-musicians, confirmed a beneficial effect of musical practice on
441 executive control, and highlighted a more anterior distribution of the P3 wave in musicians,
442 suggesting successful functional reorganization in elderly musicians according to the authors.
443 Moreover, longitudinal studies showed that 6 months of piano lessons given to older non-
444 musicians adults could improve working memory and executive functioning (Bugos et al.
445 2007, Seinfeld et al. 2013). In older actors, Banducci *et al.* (2017) reported modifications on

446 verbal long term-memory and fluency after a 4-month theatrical intervention in older adults
447 which suggests a cognitive benefit even after a short period of active art practice. While we
448 reported better performances on verbal long-term memory and fluency for Actors compared
449 with Controls, we could not find any significant difference in the elderly for Actors relative to
450 Musicians. These results must to be taken with caution with regard to the small sample size of
451 the older Actors (n=15) and would require further investigation to confirm stronger verbal
452 cognition associated with theatrical practice in aging.

453 In line with several studies on musicians that suggested no association between
454 practice time and cognitive functions (e.g., Fauvel et al. 2014; Mansen et al. 2017), our results
455 did not reveal any effect of the number of years of practice on assessed cognitive functioning.
456 Thus, having a regular and current practice appears to better explain the cognitive differences
457 we studied rather than years of practice. These results are interesting, as even a short period of
458 practice can lead to an improvement in cognitive performance in adults across the lifespan.
459 There is a growing consensus toward aging brains remaining plastic and consequently
460 involvement in leisure activities such as music or theatre remains of significant interest since
461 it is possible to start this type of practice at any age (Noice et al. 2014).

462 These findings are constrained by several limitations that need to be considered in
463 future research. First, our study is essentially descriptive because of its correlational approach
464 and does not allow us to validate causality. Only future interventional or follow-up studies
465 could confirm these results. Second, we partially evaluated the working memory abilities
466 because working memory updating ability was not assessed, as the digit backward span was
467 not among the cognitive assessment. Future studies could aim at specifying music and
468 theatrical practice differential effects on this cognitive process. Third, musicians and actors
469 differed in their average years of practice, musicians showing a longer practice duration than
470 actors. Although this variable was included as covariate in analyses without significant
471 interactions, it could have explained some of the cognitive differences between our groups.
472 Four, global cognitive functioning was not assessed, but no participant was below the passing
473 score in more than one cognitive measure, in line with preserved overall cognitive
474 performance. Furthermore, although power analyses and previous work support the selected
475 sample size, future studies should investigate cognitive differences between older musicians
476 and actors with a larger sample size.

477 To conclude, our results suggest that artistic practices can account for different
478 individuals' aging trajectories (Raz & Kenedy, 2009), and that regular artistic practice could
479 promote the constitution of cognitive and cerebral reserve (Stern, 2009; Stern et al. 2018).
480 Therefore, promoting access to artistic practice could help people maintaining or even
481 improving their cognition, besides the obvious and well-documented interest such activities
482 have on socialization (Belgrave, 2011); well-being (Noice et al. 2004; Castora-Blincket et al.
483 2010) and developing creativity (Reynolds et al. 2016; Salimpoor & Zatorre 2013). In line
484 with the evidence reviewed by Sutcliffe et al. (2020) on music training and cognition on
485 aging, our study suggests that musical or theatrical practices, even started late in life, could
486 have an effect on cognitive decline. Ferreira et al. (2015) suggested associations between
487 specific activities and the functioning of individual cognitive domains. Results suggest that
488 cognitive training programs could be individually adjusted to observed cognitive deficits
489 following a neuropsychological assessment, without making it a unique criterion for choosing
490 such activity of course. However, previous works on cognitive interventions for aging and
491 dementia showed mixed results (e.g., Alves et al., 2013). In future clinical researches it would
492 be interesting to determine whether theatrical interventions could improve language and
493 episodic memory processes for people with deficits in these domains. Conversely, as both
494 previous works and our results highlight the possible positive effect of musical practice on

495 executive functioning (Mansens et al. 2018; Koshimori and Thaut 2019; Platel & Groussard
496 2020), it seems relevant to specify the effect of musical practice interventions for people with
497 deficits in these processes.

498

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503 **Authors Statement:** MG and HP conceived the study and coordinated the collect of data.
504 MG and TH performed statistical analysis. MG wrote the first draft of the manuscript and RC,
505 TH and HP revised the different version of the manuscript. All authors approved the
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507

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