Assessment of Cognitive Functions in Nonagenarians with Different Educational Levels Comparing Controls and Alzheimer’s Patients

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Abstract

Objective: This study aimed to assess elderly nonagenarians without a diagnosis of dementia and compare them with a group of Alzheimer’s patients in measures of cognitive functions such as executive functions and verbal fluency. 30 patients without diagnosis of dementia and 41 diagnosed with Alzheimer’s disease, male and female, attending an outpatient geriatrics clinic in Brazil were clinically and neuropsychologically assessed.

Methods: Patients undergone clinical anamnesis and neuropsychiatric testing, via the Mini-Mental State Examination (MMSE) (Folstein et. al, 1975), the Verbal Fluency (VF) - Version Animals, Fruits and Words with letter ‘M’ (Brucki et. al, 2003), the Geriatric Depression Scale (GDS), abbreviated version with 15 items (Yesavage et. al, 1983) and the Functional Activities Questionnaire Pfeffer (PFAQ) (Pfeffer et. al, 1982). Results showed higher means in Verbal Fluency test – Animal version in groups of lower schooling. Another important result was the lack of statistical correlation between schooling and cognitive testing. MMSE seems to be the best tool to differentiate Alzheimer’s dementia in nonagenarians, except for a highly educated population.

Results: The results obtained point to the possibility of variation in cognitive measures of nonagenarians, from normal development to the ones affected by Alzheimer’s disease. In addition, the instruments used, might be a reference for the diagnosis of those conditions in that age group.

Conclusion: As life expectancy increases, more studies regarding elderly people’s cognitive functions are needed to help developing health care policies for that population.

Keywords: Psychological Assessment; Learning; Elderly; Gerontology; Cognition

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1. Introduction

Life expectancy is increasing in developing countries. The rapid increase in the number of aging people has caused an explosion in scientific research, in natural sciences as well as in humanities (Baltes, 1995). The constantly increase in population’s age leads to a reconfiguration in areas of health service, whose staff will have to specialize in techniques adapted to that age group (Argimon, 2005).

Historically, the aging process was associated with a decline in cognitive and biological functions, as well as increased dependence in social resources. However, current research reveals the existence of numerous aging patterns, suggesting that this process is a heterogeneous individual experience (Neri and Freire, 2000). Regarding cognition, Bee (1997) states that from 65 to 75 years there are some subtle cognitive changes, or even non-existent ones as in the case of vocabulary knowledge, however, there are significant declines in measures involving speed and non-exercised abilities. Other studies, such as Papalia and Olds (2000) highlight that in healthy elderly subjects, brain changes are generally modest, and do not create impact on daily activities. When a central nervous system disease appears, there may be an impairment in cognition, worsening performance on cognitive tests (especially tests of time control), that can interfere with the ability to learn and remember. Aging of the nervous system per se shows changes with a reduction in the number of neurons, nerve conduction speed, intensity of the reflections, restriction in motor responses, and the ability to react and coordination skills (De Vitta, 2000).

Gallahue and Ozmun (2005) find that in the period ranging between 20 and 90 years, there is a loss of 10% to 20% cerebral cortex mass, which can reach 50% in other parts of the brain. Thus, as the brain ages, biochemical activity is affected. The intellectual capacity of the elderly can be maintained without brain damage up to 80 years, according Cançado and Horta (2002). However, minor difficulties in learning and forgetting can be included along with few subtle changes that normally occur in the elderly up to 70 years (Cançado and Horta, 2002). The risk of cognitive decline in the elderly has been associated with factors intrinsic and extrinsic to the individual. Literature have highlighted factors such as low education, advanced age, hypertension, history of stroke (Magalhães et al., 2008), comorbidities, little social contact, poor intellectual activity, smoking, living alone, physical inactivity and negatively perceived health (Oliveira et al., 2007). Depression is also a risk factor, which may precede the development of dementia or coexistence with the disease (Carthey-Goulart et al., 2007).

Also according to Neri (2010) autonomy is directly related to functional capacity. Functional capacity suffers decline (normal and pathological) with age and involves the elderly physical, social, environmental and cognitive conditions (Formiga, et al., 2000). Although the concept of autonomy is closely related to the individual’s intellectual abilities in a clinical viewpoint, functional capacity, or functioning without help in daily activities are good predictors of autonomy in old age. Another point to be considered in functional capacity is related to cognitive abilities of the elderly. The decline of cognition, prevents the individual to make decisions, contributes to dependence on the achievements of activities and interferes with their autonomy and quality of life all observed in psychological tests’ results (Neri, 2010; Ribeiro et. al, 2007; Schmidt, Dal-Pizzol; Xavier; Heluany, 2009).
Among methods of assessment of cognitive deterioration, procedures using neuropsychological features have been used with significant predictive value, especially concerning the individual performance, specifically for presenting complex assessments as in the case of evaluating factors of memory, executive function, language, comprehension and other skills and/or cognitive functions (Agrell et al, 1998; Argimon et al, 2005; Heinik et al, 2003; Nitrini et al, 2005). In this sense, assessment with neuropsychological components involves systematically intensive study of factors and/or skills involved in brain functioning, with emphasis on multidimensional phenomenon (Montiel, 2005). According to such parameters, evaluation should elicit explanations of models of undamaged and altered cognitive performance and develop conclusions about such processes and cognitive abilities.

Frisoni and colleagues (1999) found that mild cognitive impairment was associated with physical problems in the elderly (75-95 years). Thilers, MacDonald and Herlitz (2006) correlated the free testosterone index and cognitive decline in people from 30 to 90 years showing different results for women and men, with free testosterone in men apparently having a positive effect on cognition. Guo et al (1998) correlated cognitive impairment and the risk for hip fractures in elderly subjects over 75 years and found that patients with cognitive deficits were more prone to hip fracture than patients without cognitive impairment.

Despite studies reporting disorders of cognition, memory impairment and dementia episodes, there are no studies in the literature about cognition of elderly people over 90 years without memory impairment, especially if compared to other problems that affect cognition such as Alzheimer's disease. Those are even more uncommon in Brazil since life expectancy in 2010 according to IBGE was 73.48 years for both sexes. Therefore the aim of this study was to compare the cognitive aspects of elderly people aged over 90 years with and without an Alzheimer's disease diagnosis.

2. Methods/Participants

Experimental Methodologies

Control Group

30 elderly patients, aged over 90 years, male and female, attending a geriatric outpatient clinic in a country town of São Paulo state, who did not meet the criteria for the diagnosis of dementia according to DSM-IV (APA, 1994) participated in this study. Memory complaints of the patients were also investigated although after clinical and neuropsychiatric evaluation participants did not meet the criteria for dementia. The Geriatric Depression Scale (GDS) was used to assess depressive symptoms and patients who scored above 7 points were not included in the research. The Functional Activity Questionnaire (Pfeffer et al, 1982) was completed by a close family member to investigate the decrease in performance on daily life activities.

Subjects younger than 89 years who satisfied the DSM-IV (APA, 1994) criteria for dementia, history of stroke, visual impairment and severe motor, parkinsonism, major depressive disorder were not included, as well as participants who did not accept completing the neuropsychometric tests. An average age equal to 92.67 (minimum = 90, maximum = 103, standard deviation [SD] = 3.11) was found in the sample, with female subjects more prominent (16 women; 53.33%). Levels of
schooling were divided into four, with a total of 4 subjects (13.33%) being illiterate, 19 (63.34%) with 1-4 years of schooling, 3 (10%) between 5-8 years and 4 (13.33%) over 9 years of schooling.

**Experimental Group**

41 elderly patients, aged over 90 years, male and female, attending a geriatric outpatient clinic in a country town of São Paulo state, who met the diagnostic criteria of dementia according to DSM-IV (APA, 1994), combined with criteria for Alzheimer’s disease from the National Institute on Aging/Alzheimer’s Association (McKhann et. al, 2011) participated on this research. The Functional Activities Questionnaire (Pfeffer et. al, 1982) was completed by a close family member, after clinical and neuropsychiatric assessment, in order to collect the most relevant information on performance impairments in everyday activity.

Exclusion criteria were subjects younger than 89 years, with severe dementia (Clinical Dementia Rating> 3), who had a history of stroke, parkinsonism, diagnosed with major depressive disorder, decline in motor activity caused by sequelae of other comorbidities, or severe visual impairment, as well as the ones who did not accept to participate on the study. The majority of participants were females (73.17%), and the average age of the sample was 91.71, ranging from 90 to 99 years (standard deviation [SD] = 2.30). Regarding education, 9 (21.95%) were illiterate, 18 (43.90%) with 1-4 years of schooling, 8 (19.51%) with 5-8 years, and 6 (14.64%) over 9 years of schooling. Table 1 indicates that no significant differences were found between the groups regarding sample characteristics. Hence, these two groups are similar in these aspects.

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>Experimental Group</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>92,67 (3,11)</td>
<td>91,71(2,30)</td>
<td>0.308</td>
</tr>
<tr>
<td>Sex</td>
<td>53% women</td>
<td>73%women</td>
<td>0.069</td>
</tr>
<tr>
<td>Schooling years Iliterate</td>
<td>13,33%</td>
<td>21,95%</td>
<td></td>
</tr>
<tr>
<td>Schooling years 1-4</td>
<td>63,34%</td>
<td>43,90%</td>
<td></td>
</tr>
<tr>
<td>Schooling years 5-8</td>
<td>10%</td>
<td>19,51%</td>
<td></td>
</tr>
<tr>
<td>Schooling years over 9</td>
<td>13,33%</td>
<td>14,64%</td>
<td>0.142</td>
</tr>
</tbody>
</table>

Significance obtained by X² test.

**3. Instruments and Procedures**

Patients undergone clinical anamnesis and neuropsychiatric testing, via the *Mini-Mental State Examination* (MMSE) (Folstein et. al, 1975), the *Verbal Fluency (VF) - Version Animals, Fruits and Words with letter ‘M’* (Brucki et. al, 2003), the *Geriatric Depression Scale* (GDS), abbreviated version with 15 items (Yesavage et. al, 1983) and the *Functional Activities Questionnaire Pfeffer* (PFAQ) (Pfeffer et. al, 1982) The project was approved by the Ethical Committee, number 54/11.

We estimated the means and standard deviations of the measures in the two groups and analyzed the size effects by means of Cohen’s d. Values above 0.8 are considered high size effect(Cohen, 1988).
4. Results and Discussion

Table 2 below shows the results of MMSE scores in both experimental and control groups. Regarding MMSE scores in the experimental group, dividing the sample by level of education, results show means below the average cutoff point, according to scores suggested by Bucki et al. (2003). In the control group, results show that only groups with 5-8 and above 9 years of schooling scored below the cutoff suggested by Brucki et al (2003), respectively 26 and 28 points.

Regarding data obtained with the Animals’ version of VF, the experimental group, all four groups scored very similarly, as shown in Table 2. The Words with Letter ‘M’ version of FV shows lower means when compared to the other version of this test. The averages shown in all versions of the verbal fluency test in all educational groups were below the cutoff point suggested by Brucki et al (2003) where they found a cutoff equal to 9 for illiterates, 12 schooling for 1-8 years and 13 schooling for over 9 years.

In the control group, means were higher in the Animals version of the VF in less schooling sample. The results obtained with the Words with Letter ‘M’ version of the VF called the attention for it was predicted a greater influence of education on the scores of this test and the illiterate sample would present lower means when compared to other groups. However, the illiterate group scored 6.25 (minimum = 0, maximum = 10, SD = 4.79) in that test (Table 2).

The Pfeffer Questionnaire of Functional Activities was conducted in order to verify functionality of the participants in the experimental group. According to the authors, a score above 5 points in the QAQP suggests a decrease in daily activities. The groups with less years of schooling presented higher impairment. Results showed means above the cutoff points suggested by Pfeffer et. al (1982) at all levels of schooling indicating impairment in performing daily activities.

When performance is related to gender, male participants in the experimental group have inferior means in MMSE test (16.64) and the Animal version of the FV (7.27). Female participants have poorer performance in the QAFP (17.61), the Fruit version of the FV (6.58) and Words with Letter ‘M’ (3:11). In the control group, male participants performed better in the MMSE (mean = 26.57, minimum = 22, maximum = 29, SD = 2.21), Animals version of the FV (mean = 12.29, minimum = 8, maximum = 17, SD = 2.95) and Words with letter ‘M’ (mean = 8.1, minimum = 3, maximum = 14, SD = 3.14 ); female participants scored higher means only in the Fruits version of the FV (mean = 9.6, minimum = 6, maximum = 13, SD = 2.20).

Considering the results of the effect size of the mean differences found in the control and experimental groups in the MMSE and the Verbal Fluency test measurements, it was observed that the differences produced significant effects on the MMSE with coefficients ranging from medium to medium high (Cohen, 1988) at all levels of schooling (values above 0.8 are considered high). The lower effect was in patients with high levels of schooling, suggesting that differences between AD patients and controls are lower in that group.

Lower effects between control and experimental groups were found in the FV test for people with 5-8 years schooling. The highest effect was found in the group over 9 years of schooling in Words with Letter ‘M’ test, followed by the group with 1-4 years schooling, and the illiterate group in the
Fruits and Animals, respectively. It can be suggested that fruits and animals categories generate higher differences in Alzheimer patients and low schooling nonagenarians, while Words with Letter M, in the higher schooling group.

This may be due to the complexity level of the requested task, being worth investigating difficulty levels for this test through other procedures as the item response theory, which invites further investigation. Nevertheless, the MMSE seems to be the best tool to differentiate Alzheimer's dementia in nonagenarians, except for a highly educated population. It also must be regarded as a limited result the small number of patients in each group. However, because this age group is so rare a sample to be investigated, we believe it is an important description aiming the strategies for caring at those ages, since life expectancy is increasing every year.

It is worth noting that, in the experimental group, all means are lower than the control group in every cognitive task measured. However, there is a progression of those values related to years of schooling, whereas in the control group means in Verbal Fluency and MMSE tests do not follow a progressive regular pattern, which is a particularity of this sample, for some participants with lower levels of schooling obtained means above the ones with higher levels of schooling.

Nevertheless, the results obtained speculate the possibility of variation in cognitive measures of nonagenarians, from normal development to the ones affected by Alzheimer’s disease with the instruments used, being a reference for the diagnosis of those conditions in that age group. The examination of differences by level of CDR, or even the analysis of the developmental course of those measures with younger subjects until reaching that age is still to be done, in order to better characterize the curve of development of cognitive measures at that age.

Table 2 Scores of MMSE divided by grade levels for the group of nonagenarians control and experimental

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>sd</th>
<th>Cohen’s d</th>
<th>Effect size r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illiterate - Experimental</td>
<td>9</td>
<td>14,56</td>
<td>7</td>
<td>19</td>
<td>3,39</td>
<td>2,46</td>
<td>0,77</td>
</tr>
<tr>
<td>Illiterate - Control</td>
<td>4</td>
<td>23,75</td>
<td>19</td>
<td>28</td>
<td>4,03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 4 years - Experimental</td>
<td>18</td>
<td>16,06</td>
<td>9</td>
<td>28</td>
<td>5,44</td>
<td>2,39</td>
<td>0,76</td>
</tr>
<tr>
<td>1 to 4 years - Control</td>
<td>19</td>
<td>26,10</td>
<td>22</td>
<td>29</td>
<td>2,38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 to 8 years - Experimental</td>
<td>8</td>
<td>18,25</td>
<td>14</td>
<td>24</td>
<td>3,33</td>
<td>2,09</td>
<td>0,72</td>
</tr>
<tr>
<td>5 to 8 years - Control</td>
<td>3</td>
<td>23,67</td>
<td>22</td>
<td>25</td>
<td>1,53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 9 years - Experimental</td>
<td>6</td>
<td>21,33</td>
<td>10</td>
<td>25</td>
<td>5,64</td>
<td>1,40</td>
<td>0,57</td>
</tr>
<tr>
<td>&gt; 9 years - Control</td>
<td>4</td>
<td>27</td>
<td>26</td>
<td>28</td>
<td>0,82</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N = number of participants; Min = minimum; Max = maximum, SD = standard deviation
Table 3 Values of the Verbal Fluency test version animals, fruits and words with the letter "M", divided by grade levels

<table>
<thead>
<tr>
<th>Group</th>
<th>Test</th>
<th>N</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>sd</th>
<th>Cohen's d</th>
<th>Effect size r</th>
</tr>
</thead>
<tbody>
<tr>
<td>illiterate</td>
<td>FV animals</td>
<td>9</td>
<td>7,11</td>
<td>2</td>
<td>15</td>
<td>3,52</td>
<td>1.68</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>FV fruits</td>
<td>9</td>
<td>7,11</td>
<td>2</td>
<td>10</td>
<td>2,52</td>
<td>1.43</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>FV &quot;M&quot;</td>
<td>9</td>
<td>2,67</td>
<td>0</td>
<td>11</td>
<td>2,60</td>
<td>0.92</td>
<td>0.42</td>
</tr>
<tr>
<td>1 to 4 years</td>
<td>FV animals</td>
<td>18</td>
<td>7,33</td>
<td>1</td>
<td>18</td>
<td>4,32</td>
<td>1.04</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>FV fruits</td>
<td>18</td>
<td>6,12</td>
<td>3</td>
<td>10</td>
<td>2,39</td>
<td>1.83</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>FV &quot;M&quot;</td>
<td>18</td>
<td>3,35</td>
<td>0</td>
<td>8</td>
<td>2,40</td>
<td>1.44</td>
<td>0.60</td>
</tr>
<tr>
<td>5 to 8 years</td>
<td>FV animals</td>
<td>8</td>
<td>8</td>
<td>3</td>
<td>12</td>
<td>3,02</td>
<td>0.10</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>FV fruits</td>
<td>8</td>
<td>6,71</td>
<td>5</td>
<td>9</td>
<td>1,90</td>
<td>0.96</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>FV &quot;M&quot;</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>8</td>
<td>2,24</td>
<td>0.08</td>
<td>0.04</td>
</tr>
<tr>
<td>&gt; 9 years</td>
<td>FV animals</td>
<td>6</td>
<td>8,5</td>
<td>2</td>
<td>12</td>
<td>3,67</td>
<td>0.72</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td>FV fruits</td>
<td>6</td>
<td>7,6</td>
<td>3</td>
<td>12</td>
<td>3,29</td>
<td>1.10</td>
<td>0.48</td>
</tr>
<tr>
<td></td>
<td>FV &quot;M&quot;</td>
<td>6</td>
<td>5,2</td>
<td>3</td>
<td>7</td>
<td>1,48</td>
<td>3.63</td>
<td>0.87</td>
</tr>
</tbody>
</table>

N = number of participants; Min = minimum, Max = maximum, SD = standard deviation.
In fact, it is important to consider Brazil as a country with a large number of elderly people (Garcez-Leme et al., 2005). In this research, it was shown that even scoring below the cutoff on some items was not enough for participants to receive a diagnosis of dementia. It is evident the influence of age as a variable in cognitive tests and low scores presented. Consequently, Valls et Pedret. al (2011) argue for the essential participation of age as a variable in cognitive tests. This research showed that the youngest group, from 50 to 60 years, reached higher scores when compared to the elderly group (over 80 years), that is, differences were found in test scores even among the elderly who showed no evidence of dementia demonstrating the influence of age as a variable.

Regarding years of education, several studies corroborate the results found in this research, as it was observed that elderly people with more years of schooling score higher in cognitive tests (Brito-Marques et. al, 2005; Diniz et. al, 2007; Matallana et. al, 2011; Pedret-Valls et. al, 2011; Schmidt; Dal-Pizzol; Xavier and Heluany, 2009).

Specifically for the elderly, literature seem to focus on groups of normal patients, or with other health issues like testosterone levels, or fractures (Frisoni et al, 1999; Thilers, MacDonald and Herlitz, 2006), but not Alzheimer's disease, for example. Indeed, the cognitive decline observed in this disease was apparently due to the different kind of tests employed and the complexity of their requested tasks. Also schooling affected progression by age in the screening of cognitive measures of the MMSE and the Verbal Fluency test in the control group, aspects which were not discussed in other studies and that invite further investigation.

5. Final Considerations

With the increase in population’s life expectancy, new social conditions emerge as a challenge to the field of gerontology and other social associations. Within the family, the most challenging situation refers to the assistance to the elderly, for since women now are working outside the home the elderly tend to be left alone. In that sense, there is a shortage of qualified staff to deliver basic health care to an aging population. The main government investment in Brazil is focused in younger groups (children and teenagers) and there is a lack of public policies investing in improving life quality of elderly people.

Finally, results of this research support the need for new studies involving that population, especially due to their particular cognitive features and the possible correlations with diverse cognitive aspects that may decline with aging.

List of contributions

- Fruits and animals categories of VF generate higher differences in Alzheimer patients and low schooling nonagenarians, while Words with Letter M, in the higher schooling group.

- MMSE seems to be the best tool to differentiate Alzheimer's dementia in nonagenarians, except for a highly educated population. However, because this age group is so rare a sample to be investigated, we believe it is an important description aiming the strategies for caring at those ages, since life expectancy is increasing every year.
The results obtained indicate the possibility of variation in cognitive measures of nonagenarians, from normal development to the ones affected by Alzheimer’s disease. In addition, the instruments used might be a reference for the diagnosis of those conditions in that age group.

Statement of Conflicts of Interest

All authors affirm no conflict of interests by any other group or persons who might hinder the publication of this manuscript.

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