Relationship between plasticity, mild cognitive impairment and cognitive decline

M. Dolores Calero*, Elena Navarro
Department of Personality, Psychological Assessment and Treatment, School of Psychology, Facultad de Psicología, Universidad de Granada, Campus La Cartuja, University of Granada, 18071 Granada, Spain

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Abstract

A topic of great interest in gerontology research is the prediction of cognitive deterioration which marks the transition from mild cognitive impairment (MCI) to dementia. In this area the term plasticity is a construct of prime importance. Previous studies have demonstrated the existence of plasticity in healthy older persons, and it is thought that this is what discriminates between healthy individuals and those at risk for dementia. The aim of the present study is to demonstrate that plasticity exists in persons with MCI, and that a lack of plasticity may be one of the risk factors related to cognitive decline. An adapted version of the Auditory Verbal Learning Test—the AVLT of Learning Potential—was used to assess plasticity. Participants in the research were 203 older persons whose cognitive status had previously been determined using a cognitive screening test. The results show that plasticity exists in persons with MCI and that its presence is associated with less marked cognitive decline.

Keywords: Mild cognitive impairment; Plasticity; Cognitive decline; AVLT

1. Introduction

For some time the evolution of cognitive status in the older persons was considered to reflect a universal, cumulative process of decline. In the 1970s, dissatisfaction with this limited point of view led to research into plasticity (developmental reserve capacity) and to the search for evidence that the process is in fact multidimensional and multidirectional, with many different individual trajectories (Baltes, 1987).

*Corresponding author. Tel.: +34-58-243754; fax: +34-58-243749.
E-mail address: mcalero@ugr.es (M.D. Calero).

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In this new conception of cognitive evolution in older persons, the distinction between performance (a person’s present state of ability) and plasticity (potential for performance to improve) has acquired great importance. This concept reflects a far more optimistic and interventionist view about older persons (Baltes & Willis, 1982).

Initially, different research groups focussed on demonstrating the existence of cognitive plasticity in older persons (refer to Verhaeghen’s meta-analysis, 2000). Later, attention turned to establishing the limits of plasticity (i.e., Willis & Schaie, 1986), while the most recent studies have investigated individual differences in plasticity. With regard to this third objective, studies by Baltes and colleagues (Baltes & Baltes, 1997; Baltes & Kühl, 1995; Baltes, Kühl, & Sowarka, 1992) show significant differences in plasticity between older persons at risk for dementia and healthy older persons. Their analysis leads them to conclude that the ability to learn is disproportionately reduced in persons with, or at risk for, dementia. Consequently, several studies by these authors have been concerned with establishing and investigating the discriminatory power of techniques that evaluate plasticity with regard to the risk of dementia (Baltes & Raykov, 1996; Raykov, Baltes, Neher, & Sowarka, 2002). Although these results found by Baltes and colleagues, other authors (Bäckman, 1996; Heun, Burkart, & Benker, 1997a, 1997b) have shown that under certain circumstances, persons with MCI or even dementia are able to learn, as documented by the presence of plasticity.

These conclusions are particularly interesting in the light of recent studies that document the relationship between age and dementia. For example, The Berlin Aging Study (Baltes & Ulrich Mayer, 1999) finds that at 70 years of age, only 17% of older persons show cognitive deterioration, while at 90 years of age, 50% of the subjects show cognitive deterioration. This effect of age is compounded by the fact that older persons with mild cognitive deterioration (MCI) often develop dementia in only a few years (Collie & Maruff, 2000; Petersen, 2000; Ritchie & Touchon, 2000). In this context, many studies have focused on analyzing the characteristics of older persons with MCI in order to identify factors that contribute to their decline, and to develop techniques which might permit the early diagnosis of MCI as a way to forestall the severe losses due to dementia (Bozoki, Giordani, Heidebrink, Berent, & Foster, 2001; Collie & Maruff, 2000; Shah, Tangalos, & Petersen, 2000).

The basic aim of the present study is to show that plasticity is not directly related to mild cognitive deterioration. This implies that some older persons with MCI would be expected to show significant learning similar to that displayed by persons without MCI in a test of plasticity. It is hoped that the present report will shed light on the relationship between plasticity and cognitive deterioration, since in our view this variable may constitute a useful prognostic indicator to predict the course of cognitive decline. We therefore followed part of the initial sample of participants to determine their cognitive status 1 and 2 years after training, to determine how cognitive status is related with the presence or absence of plasticity in the initial part of the study.

Of the various techniques for assessing plasticity, we chose a version of the Auditory Verbal Learning Test of Learning Potential (AVLT-LP). This choice was informed by research that suggested a possible relationship between declining performance in semantic memory tests and rapid cognitive deterioration (Bozoki et al., 2001; Petersen et al., 1994, 1997). Moreover, the AVLT-LP has been shown to be valid as a tool to evaluate plasticity in older persons and in other populations (Wiedl, Schöttke, & Calero, 2001; Wiedl, Wienobst, & Schöttke, 1999).
2. Methods

2.1. Participants

A total of 203 older Spanish persons were recruited from long-term care centers and general medicine clinics in the province of Granada (southern Spain). Average age was 74.74 (S.D. 8.56) years, with a range of 60–93 years. About half (54.5%) of participants were women and 45.5% were men. A slight majority (59.3%) of the participants had received no formal education; 40.7% had received primary or secondary schooling.

2.2. Instruments

Mini Examen Cognoscitivo (MEC; Lobo, Escobar, Esquerra, & Seva Díaz, 1979): This is the Spanish version of the Mini-Mental State Examination (MMS) of Folstein, Folstein, and McHugh (1975), translated and adapted by Lobo et al. (1979). In this version the maximum score is 35. To establish criteria for the presence or absence of cognitive impairment we used standards developed for the Spanish population by Manubens et al. (1998). The validity of these standards was confirmed by us in a previous study (Calero, Navarro, Robles, & García-Berben, 2000).

Auditory Verbal Learning Test of Learning Potential (Wiedl et al., 1999): This is the classic Rey’s Verbal Learning Test (Rey, 1964) adapted to measure plasticity. In the AVLT-LP version, the list of 15 words is presented six times consecutively. The initial two presentations (A1, A2) are considered the pretest and therefore follow the standard procedure; the following two presentations (A3, A4) constitute the training. This part consists of the administration of reinforcement, feedback about performance in the preceding part, repetition of the words not recalled, and verbalizations aimed at focusing the participant’s attention on the task. The two final presentations of the list of words (A5, A6) represent the posttest and therefore again follow the standard procedure. Previous research (Wiedl et al., 2001) into this form of applying the test shows that the training given in the intermediate presentations significantly improves performance, thus demonstrating its validity as a test to measure plasticity. The results can be interpreted with an algorithm of Schöttke, Bartram, and Wiedl (1993), whereby a subject is classified as a gainer when his or her improvement (pre–post difference in score) is above 1.5 S.D. of the pretest score. In other words, a gain of more than 2.5 points (pre–post difference) in the AVLT-LP indicates plasticity (learning capacity) in the participant.

2.3. Data collection

Participants were selected on the basis of previous reports by staff members who identified patients with certain symptoms indicating possible MCI. Each participant was assessed individually in one session. The sample group was divided into two subgroups on the basis of scores on the MEC. The cutoff point was adjusted for educational level according to previous data proposed by Escribano-Aparicio et al. (1999), Manubens et al. (1998), and Blesa et al. (2001) for the Spanish population. To follow the evolution of cognitive performance and its
relation with plasticity detected in the first part of the study, we again studied 55 (27.09\%) of the original participants after 1 year, and 23 participants (11.33\%) after 2 years.

2.4. Statistical analysis

To establish the differences in learning between persons with and without MCI we used a linear 2 × 2 model with test application (A1, A2, etc.) of the AVLT-LP as the intraindividual factor, and presence or absence of MCI as the interindividual factor. Chi-squared analysis was used for the results for participants with and without MCI, and for participants with and without plasticity. Tests of the differences between dependent samples were used to determine the relationship between plasticity and cognitive decline 1 and 2 years after the initial study. All statistical analyses were done with SSPS software.

3. Results

The results of the multivariate analysis with Pillai’s trace showed significant intraindividual differences for the overall sample of participants between successive applications of the AVLT-LP ($F[197] = 127.748; P < .001$). The interindividual effect was also significant ($F[1] = 50.99; P < .001$).

When performances on the AVLT-LP were analyzed separately for participants with and without MCI, multivariate analysis with Pillai’s trace showed significant differences between successive applications of the test both in the group without MCI ($F[98] = 75.541; P < .0001$) and in the group with MCI ($F[99] = 50.471; P < .0001$). Within each group there were significant intraindividual differences between successive applications of the AVLT-LP, with the exception of the difference between the A4 (end of training) and the A5 score. As shown in Table 1, the differences between the mean scores for the different applications of the test were significant at the .05 level in both groups. The results of the chi-squared analysis again confirmed the presence of persons with plasticity in both the MCI and non-MCI groups. Table 2 shows that there was no difference ($\chi^2 = 1.329; P > .1$) in the percentage of persons with plasticity between the MCI and the non-MCI group. In other words, there does not seem to be any relationship between cognitive impairment and absent or low plasticity.

<table>
<thead>
<tr>
<th>Applications of the AVLT-LP</th>
<th>Difference of the means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MCI</td>
</tr>
<tr>
<td>A1–A2</td>
<td>−1.42*</td>
</tr>
<tr>
<td>A2–A3</td>
<td>−0.81*</td>
</tr>
<tr>
<td>A3–A4</td>
<td>−0.4*</td>
</tr>
<tr>
<td>A4–A5</td>
<td>−0.23</td>
</tr>
<tr>
<td>A5–A6</td>
<td>−0.47*</td>
</tr>
</tbody>
</table>

* Difference of the means was significant at the .05 level.
Table 2
Distribution of the participants according to plasticity and cognitive status

<table>
<thead>
<tr>
<th></th>
<th>Plasticity</th>
<th>No plasticity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCI</td>
<td>47</td>
<td>55</td>
<td>102</td>
</tr>
<tr>
<td>Non-MCI</td>
<td>72</td>
<td>29</td>
<td>101</td>
</tr>
<tr>
<td>Total</td>
<td>119</td>
<td>84</td>
<td>203</td>
</tr>
</tbody>
</table>


Table 3
Mean scores on the MEC at follow-up, and differences between dependent samples

<table>
<thead>
<tr>
<th></th>
<th>MEC 1, mean (S.D.)</th>
<th>MEC 2, mean (S.D.)</th>
<th>Difference between MEC 2 and MEC 1</th>
<th>MEC 3, mean (S.D.)</th>
<th>Difference between MEC 3 and MEC 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persons with plasticity ((N = 119))</td>
<td>26.5 (4.73)</td>
<td>27.5 (5.67)</td>
<td>(t(27) = -0.71)</td>
<td>24 (9.19)</td>
<td>(t(1) = 1.4)</td>
</tr>
<tr>
<td>Persons with no plasticity ((N = 84))</td>
<td>24.5 (5.53)</td>
<td>24.5 (3.53)</td>
<td>(t(22) = -0.371)</td>
<td>15 (4.24)</td>
<td>(t(1) = 19^*)</td>
</tr>
<tr>
<td>Total ((N = 203))</td>
<td>25.4 (5.47)</td>
<td>25.2 (5.45)</td>
<td>(t(52) = -1.098)</td>
<td>16.6 (4.63)</td>
<td>(t(4) = 3.28^*)</td>
</tr>
</tbody>
</table>

Note. MEC 1: initial score on the MEC; MEC 2: 1-year follow-up score on the MEC; MEC 3: 2-year follow-up score on the MEC.

* Difference of the means was significant at the .05 level.

With regard to the evolution of cognitive status in the population we studied, Table 3 shows in the ‘total’ sample, that no significant decline was seen after 1 year \(t(52) = -1.098; \ P = .518\). However, a decline was seen after the second year \(t(4) = 3.28; \ P < .05\). When the two groups were analyzed separately persons who in the initial evaluation had been classified as displaying plasticity on the basis of their performance on the AVLT-LP maintain the scores obtained on the MEC in the initial evaluations, with no significant decline in their cognitive status after 2 years \(t(1) = 1.4; \ P = .395\). In contrast, persons initially classified as lacking plasticity did show a significant decline \(t(1) = 19.0; \ P < .05\) in the follow-up tests 2 years later.

4. Discussion

The data reported here show that when we analyzed the interaction between cognitive status and plasticity, we found two types of effect in our participants: an intraindividual and an interindividual effect. Thus, although significant differences in performance were seen in relation to MCI, there were also significant differences between the scores in successive applications of the AVLT-LP within each group. These findings can and should be interpreted
as an effect of learning, both in persons without and in those with MCI. It should be emphasized here that although this learning is less evident in persons with MCI, it was nonetheless also significant. In addition, our data regarding the distribution of participants on the basis of their cognitive status and whether or not they showed plasticity indicate that both groups contained individuals with evidence of plasticity; as a consequence there was no significant difference in plasticity between the group with and the group without MCI. This leads us to suggest that plasticity should be considered a variable compatible with mild cognitive impairment (MCI), rather than as a diagnostic criterion.

Despite the small number of participants in the follow-up sessions used to track the evolution of cognitive functioning, the findings are noteworthy with regard to the population studied here. Persons who were initially classified as having plasticity on the basis of their performance on the AVLT-LP maintained this performance during follow-up, with no cognitive decline after 1 and 2 years. Our results lead us to suggest, tentatively, that plasticity is an indicator of cognitive decline, and that it may therefore be a factor that marks the transition from MCI to dementia. However, because of the limitations of the data available in the present study, and in the light of the implications of the relationship we propose between plasticity and cognitive status, further judgement will need to be based on additional research into this possible link.

To sum up, we have tried to establish that the measurement of plasticity in an older person is a valid tool for identifying individuals who, although belonging to a risk group, still have a capacity to learn that is sufficient to maintain their cognitive functioning if systematic intervention is provided.

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References


