Objective cognitive functioning three months after stroke: a comparison of young, middle-aged and elderly patients
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Abstract

Objective - The aim of the current study was to investigate the differences in episodic memory, executive functioning and mental speed and attention between young, middle-aged and old adults, 3 months after stroke, compared to age-matched control groups.

Methods - 210 stroke patients and 154 controls who had participated in the COMPAS (COMplaints After Stroke) study were tested. Episodic memory, executive functioning and mental speed and attention were assessed using the Rivermead Behavioural Memory Test (RBMT), Zoo map test and Digit-Symbol Coding Test (DSCT) respectively.

Results – MANCOVAs and post-hoc tests showed that stroke patients performed more poorly on the mental speed and attention test (DSCT) than healthy controls. No differences between patients and controls were found for episodic memory and executive functioning. Main effects of age were found however for all domains, with young participants scoring best and old worst, for both stroke patients and controls.

Conclusions – Elderly people, irrespective of whether they have had a stroke or not, did more poorly on a variety of cognitive tests than younger participants. For stroke patients however, mental speed and attention was especially affected by age. That is why it could be suggested that in people who are both old and have had a stroke, impaired mental speed in the first period (3 months) after stroke is apparent, more so than is the case for healthy elderly subjects.

Keywords: stroke, objective cognitive functioning, age effects
Stroke is the third leading cause of death in the Netherlands, while 45,000 – 46,000 first ever strokes occur every year [1]. The risk of stroke increases with age, this relationship is universally found across nations [2]. Although the incidence is low, roughly 10% of new strokes occur in young people [3, 4].

Age differences in stroke
There are important differences between young and old stroke patients with respect to risk factors, etiology, and gender distribution. However, the severity of stroke on admittance and short-term outcome is similar among all ages [5].

With respect to functional recovery, the prognosis for young adults with stroke is good, especially when compared with the elderly. Some studies show that up to 90% of young patients with a long-term follow-up are independent for all activities of daily living and 95% are able to walk without any assistance in spite of previous stroke [6-8]. This is in contrast with the results of studies in the elderly, which show that 35%–40% of these stroke patients are dependent on other persons [9, 10].

With regard to Quality of Life (QoL), there are both differences and similarities between young and older stroke survivors. For all age groups QoL was impaired in comparison with age-matched healthy adults [11, 12]. In older patients factors such as type of stroke, visual field impairment and seizures may be associated with QoL [12]. Reduced QoL in young patients was associated with dependence, depression, being single, fatigue, and being unemployed [13]. It has been demonstrated that about half of them had psychological disorders, especially depression or anxiety, which are mainly focussed on work, recovery and childcare [14]. Moreover, denial of the impact and permanency of the stroke, anger or
frustration, problems with social participation, as well as family conflicts, marital difficulties and sexual problems, were reported in young stroke survivors [3, 14].

Cognitive impairments after stroke

Studies by Tatemichi et al. [15] and Patel et al. [16] concluded that in three months after stroke, the frequency of cognitive impairment is about 35%. The presence of cognitive impairment in stroke patients has important functional consequences, independent of the effects of physical impairment.

Tatemichi et al. [15] concluded that memory, orientation, language and attention are the cognitive domains in which the most limitations occur in stroke survivors compared with control subjects. A study of Pustokhanova et al. [17] showed that cognitive impairment after stroke reflects decrease of frontal functions, verbal fluency and attention [17]. Hurford et al. [18] found that speed and attention were the most impaired domains. The results of these studies suggested that attention and language were the most impaired in the early stages after stroke. The mean ages of the participants in the studies of Tatemichi, Pustokhanova and Hurford are 71, 59 and 64 years respectively, so it is possible that the degree of impairment depends on age.

Hurford et al. [18] investigated the pattern of cognitive impairment in different neuropsychological domains up to a year after ischaemic stroke. They concluded that speed and attention, the most impaired domains according to their study, showed the greatest improvement over time. Also frontal executive function, perceptual and nominal skills showed strong improvements (30% impairment at 1 month dropping to under 15% at 3 months), while visual and verbal memory showed no significant change over time. Hurford et al.’s results suggest a domain-specific improvement in cognition after stroke [18].
Cognitive impairments by age

Drag et al. [19] examined the pattern of cognitive aging concluding that ‘normal aging’ is not associated with global cognitive decline, but rather that cognitive decline tends to be specific, even within domains, and is more pronounced when greater burdens are placed on cognitive resources. In fact, semantic memory actually increased with age. Conversely, other abilities, such as language and implicit memory tend to remain relatively stable over the lifetime [19]. Although specific language abilities are relatively unaffected in normal aging, difficulties may arise due to changes in frontal or sensory processes. Most problems are due to frontal inefficiency rather than pure language deficits [19].

Jolles et al.’s study [20] was in agreement with these findings; generally older adults do not perform more poorly in cognitive tasks assessing experience and knowledge. Also learned skills like riding a bicycle and reading show little changes over the lifespan. However, compared with younger people, older adults are at a disadvantage in tasks which assess concentration, attention and working memory. They also seem to experience more difficulty in tasks assessing executive functioning such as producing purposeful behaviour, handling and/or responding to new situations, setting priorities, and picking up signals from others about themselves [20].

These results support the theory of fluid and crystallized intelligence [21]. This theory says that fluid intelligence (being able to think and reason abstractly and solve problems) is considered independent of learning, experience and education. The developmental trajectory of fluid abilities is thought to follow neurological maturation, peaking in the mid-20s and thereafter declining gradually until the 60s when a more rapid decline takes place. Fluid abilities are affected by neurological insult, genetics and biological aging processes [22]. Crystallized intelligence (knowledge that comes from prior learning and past experiences, such as language and implicit memory), is based upon facts and rooted in experiences [21].
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They are less affected by aging and disease and often remain intact in the early stages of dementia or after brain injury. In contrast to fluid intelligence, crystallized intelligence continues to grow throughout adulthood [21].

Variables such as education, mental engagement, and physical activity can have positive effects on cognitive performance in later life [19]. This refers to the theory of “Cognitive Reserve”, which says that cognitive reserve is the hypothesized capacity of the mature adult brain to sustain the effects of disease or injury [23].

*Cognitive impairments after stroke by age*

One study found that stroke patients with memory deficits were older than patients without these deficits [24]. As people grow older, the risk of dementia also increases. So an explanation for this result is that comorbidity plays a role. Due to the fact that few other studies have explored the influence of age on cognitive functioning after stroke, the question remains as to whether there are differences in the pattern of cognitive impairment between young, middle and old stroke survivors. This has not been specifically studied in detail before, something the current study aimed to redress.

The aim of the current study was to investigate the differences in the pattern of objective cognitive impairment between young, middle and old adults, 3 months after stroke. The focus in this study was on the domains ‘episodic memory’, ‘mental speed and attention’ and ‘executive functioning’. These domains were chosen because impairments in these domains are common after stroke, especially early in the process. A control group was also tested to examine whether the differences in stroke patients between young, middle and old adults were similar or different to the pattern of ‘normal aging’.
The hypotheses of this study were as follows:

1) Stroke survivors will have a greater impairment in episodic memory, executive functioning and mental speed and attention than healthy control people.

2) In both patients and controls, episodic memory, executive functioning and mental speed and attention decrease by age (because these are all domains which involve fluid intelligence), resulting in lower raw scores or longer time needed to complete the tests.

3) The effect of age will be greater in patients than in controls (interaction), leading to greater cognitive impairments by aging in patients than in controls.

**Method**

*Participants*

Stroke patients from three hospitals in the Netherlands, namely the St. Elisabeth Hospital and TweeSteden Hospital in Tilburg and the Maxima Medical Centre in Veldhoven, were approached to participate in the study. Participation in the study was voluntary.

The inclusion criteria for patients in this study were: 1) clinical diagnosis of a first or recurrent ischemic or haemorrhagic stroke and 2) at least 18 years old. The exclusion criteria for patients were: 1) pre-existent health problems interfering with cognitive functioning, such as: cognitive decline, a recent history of severe psychopathology, pre-existent severe physical co-morbidity, pre-existing brain damage not caused by stroke or Transient Ischemic Attack (TIA) and 2) communication impairments.

The control group in this study consisted of people from the general population. They were recruited among the relatives and the social networks of the patients. The inclusion- and exclusion criteria for the control groups were the same as the criteria for the patients, except for the first inclusion criterion. However, spouses of stroke patients were not allowed to participate in the study, because they are at a higher risk of having physical, cognitive and
psychosocial problems themselves due to the fact that their partner has suffered a stroke [25,26].

In this study, participants under the age of 50 years were ‘young adults’, people between the ages of 50 and 65 years were ‘middle-aged adults’, and people with an age of 65 and older were ‘old adults’. In many studies the boundary between young and old adults is at the age of 50. The age of 65 is chosen because in the Netherlands that is the boundary between working and not-working people.

Matching on group level was not possible in this study, because some groups contained too few participants after matching. That is why gender and level of education (low/average versus high) were considered as covariates. The level of education was based on the Dutch Classification System by Verhage [27] (see table 11 in the Appendix). After that it was transformed into a dichotomous variable, whereby the values 1-5 meant low/average level of education, and the values 6-7 high level of education.

**Measures**

The following neuropsychological tests were used to assess cognition:

a. *Episodic memory* was assessed using the Rivermead Behavioural Memory Test (RBMT) [28]. This is an ecologically valid test which measures everyday memory problems [29].

b. *Executive functioning* was assessed using the subtest ‘Zoo map test’ from the Behavioural Assessment of the Dysexecutive Syndrome battery (BADS) [30]. The BADS is an ecologically valid test which measures executive functioning. The ‘Zoo map test’ is a test to assess the ability independently to formulate and implement a plan in a high demand condition, and to follow a formulated plan in a low demand condition [30].
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c. **Mental speed and attention** was measured using the Digit Symbol-Coding Test (DSCT) [31]. This test calls on psychomotor speed with paper-and-pencil, the ability to follow directions, short term memory, the ability to quickly shift mental sets and the capacity for sustained attention and concentration [31].

For more information and psychometric properties of the tests, see Table 1 in the Appendix.

*Design and statistical analyses*

This study is part of a larger study, the COMPAS study, which is a two-year prospective follow-up study of stroke patients and controls [32].

A cross-sectional design was employed with objective cognitive performance assessed at three months after stroke. The two independent variables in this study were ‘group’ and ‘age’. The variable ‘group’ was divided into 2 groups; stroke patients and healthy controls. The variable ‘age’ was divided into 3 groups; young, middle and old adults. These two independent variables were categorical variables. The dependent variables were the raw scores on the neuropsychological tests, these are ordinal variables.

Results of this study were analysed using SPSS for Windows version 17.0. First, descriptive statistics were used to describe the basic features of the data in the study. A two-way multivariate analysis of covariance (MANCOVA) was used to analyse the main and interaction effects of age and group for each of the dependent variables, and the separate effects of both age and group on each dependent variable. Post-hoc tests were used to examine where differences between age-categories exactly were [33,34]. In general, two-tailed p values less than 0.05 were considered statistically significant.
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Procedure

The cognitive domains were measured using a neuropsychological test battery. The tests were administered in a standardized way by trained neuropsychologists. The examination took place at the participating hospitals or, when this was not possible, at the participants’ home.

All test batteries were scored twice, by two different neuropsychologists.

Results

Descriptives of the sample are displayed in Table 2. Table 3, 4 and 5 in the Appendix show the mean raw scores on the three neuropsychological tests for stroke patients and the healthy adults, in all age categories.

Table 2: Baseline characteristics of the sample

<table>
<thead>
<tr>
<th></th>
<th>Patients</th>
<th></th>
<th></th>
<th>Controls</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Young (&lt;50)</td>
<td>Middle (50-65)</td>
<td>Old (&gt;65)</td>
<td>Total</td>
<td>Young (&lt;50)</td>
<td>Middle (50-65)</td>
</tr>
<tr>
<td>N (%)</td>
<td>28 (13)</td>
<td>71 (34)</td>
<td>111 (53)</td>
<td>210 (100)</td>
<td>34 (22)</td>
<td>73 (47)</td>
</tr>
<tr>
<td>Age, M (sd)</td>
<td>44.2 (5.8)</td>
<td>58.0 (4.2)</td>
<td>74.5 (6.4)</td>
<td>64.9 (12.4)</td>
<td>43.5 (5.5)</td>
<td>58.7 (4.4)</td>
</tr>
<tr>
<td>Gender, male N (%)</td>
<td>16 (57.1)</td>
<td>58 (81.7)</td>
<td>64 (57.5)</td>
<td>138 (65.7)</td>
<td>12 (35.3)</td>
<td>29 (39.7)</td>
</tr>
<tr>
<td>Level of education*, M (sd)</td>
<td>5.0 (1.2)</td>
<td>5.0 (1.2)</td>
<td>4.4 (1.5)</td>
<td>4.7 (1.4)</td>
<td>5.9 (0.7)</td>
<td>5.7 (0.8)</td>
</tr>
</tbody>
</table>

* Education based on the Dutch Classification System by Verhage [27], see table 11 in the Appendix.

RBMT

The MANCOVA indicated main effects for group (F(15, 337)=2.2, p=.007) and age (F(30, 674)=3.7, p=0.007). No interaction effects were found.

The significant effects of group and age for the dependent variables separately are displayed in Tables 6 and 7 respectively.
Table 6: Main effects of group

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean score patients</th>
<th>Mean score controls</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Delivering a message</td>
<td>2.6</td>
<td>2.8</td>
<td>0.044*</td>
</tr>
<tr>
<td>delayed recall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Remembering a name</td>
<td>1.4</td>
<td>1.8</td>
<td>0.012*</td>
</tr>
<tr>
<td>14. Property</td>
<td>3.2</td>
<td>3.6</td>
<td>0.01*</td>
</tr>
<tr>
<td>15. Total profile score</td>
<td>18.8</td>
<td>21.3</td>
<td>0.013*</td>
</tr>
</tbody>
</table>

* p < 0.05

An inspection of the mean scores indicated that patients scored worse on those variables than controls. In Figure 1 the mean scores and significant differences between patients and controls are displayed.

Figure 1: Mean scores and significant differences between patients and controls**

* significant differences (p<0.05)
** see table 3 in Appendix for explanation of variables
Table 7: Main effects of age

<table>
<thead>
<tr>
<th>Variables</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Story direct recall</td>
<td>0.001**</td>
</tr>
<tr>
<td>3. Route direct recall</td>
<td>0.003**</td>
</tr>
<tr>
<td>4. Delivering a message direct recall</td>
<td>0.001**</td>
</tr>
<tr>
<td>5. Recognition of faces</td>
<td>0.013*</td>
</tr>
<tr>
<td>8. Remembering an appointment</td>
<td>0.000**</td>
</tr>
<tr>
<td>9. Story delayed recall</td>
<td>0.000**</td>
</tr>
<tr>
<td>10. Route delayed recall</td>
<td>0.007*</td>
</tr>
<tr>
<td>12. Remembering a name</td>
<td>0.032*</td>
</tr>
<tr>
<td>14. Property</td>
<td>0.000**</td>
</tr>
<tr>
<td>15. Total profile score</td>
<td>0.000**</td>
</tr>
</tbody>
</table>

* p < 0.05
** significant using a Bonferroni adjusted alpha level of 0.003

Post-hoc ANOVAs were conducted to identify where exactly the significant differences were. The results of these ANOVAs are described below.

Patients

In Figure 2, the mean scores and significant differences between age categories are displayed for patients.

Old patients scored worse than the young and middle aged on the variables ‘total profile score’, ‘story direct recall’, ‘delivering a message direct recall’ and ‘story delayed recall’. Old patients scored worse than young patients on the variables ‘route direct recall’, and worse than middle patients on the variables ‘remembering an appointment’ and ‘property’. Middle-aged patients scored worse than young patients on the variable ‘remembering a name’.
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Figure 2: Mean scores and significant differences between age categories in patients**

* significant difference (p<0.05)
** see table 3 in Appendix for explanation of variables

Controls

In figure 3, the mean scores and significant differences between age categories are displayed for controls.

In controls, old adults scored worse than young adults on the variables ‘story direct recall’, ‘route direct recall’, ‘delivering a message direct recall’, ‘route delayed recall’ and ‘remembering an appointment’. Old controls scored worse than young and middle ones on the variables ‘total profile score’ and ‘property’. Old controls scores worse than middle-aged controls on the variables ‘recognition of faces’ and ‘remembering a name’. There were significant differences between all age categories on the variable ‘story delayed recall’.
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Figure 3: Mean scores and significant differences between age categories in controls**

* significant difference (p<0.05)
** see table 3 in Appendix for explanation of variables

Zoo map test

Results of the MANCOVA indicated a main effect of age (F(14, 674)=3.6, p=.000). No other significant effects were found. The main effects of age, using a Bonferroni adjusted alpha level of 0.007, are displayed in Table 8.

Table 8: Main effects of age

<table>
<thead>
<tr>
<th>Variables</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Total time condition 1</td>
<td>0.000*</td>
</tr>
<tr>
<td>3. Score condition 1</td>
<td>0.000*</td>
</tr>
<tr>
<td>5. Total time condition 2</td>
<td>0.000*</td>
</tr>
<tr>
<td>6. Score condition 2</td>
<td>0.003*</td>
</tr>
<tr>
<td>7. Total score (condition 1 + condition 2)</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

* p < 0.007

Post-hoc ANOVAs were conducted to identify where exactly the significant differences were.

The results of these ANOVAs are described below.
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Patients

In figure 4, the mean scores and significant differences between age categories are displayed for patients.

In patients, old patients scored worse than middle and young ones on the variables ‘total time condition 1’, ‘score condition 1’, ‘total time condition 2’, ‘score condition 2’ and ‘total score’.

Figure 4: Mean scores and significant differences between age categories in patients**

* significant differences (p<0.05)
** see table 4 in Appendix for explanation of variables
Controls

In figure 5, the mean scores and significant differences between age categories are displayed for controls.

In controls, there was not such a clear pattern; on the variable ‘total time condition 1’, old adults scored significantly worse than young adults. Young adults scored significantly better than middle and old ones on ‘score condition 1’ and ‘total score’. On the variable ‘total time condition 2’ old adults scored worse than middle and young ones.

Figure 5: Mean scores and significant differences between age categories in controls**

* significant differences (p<0.05)
** see table 4 in Appendix for explanation of variables
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**DSCT**

Main effects were found for group (F(2, 353)=19.3, p=0.000) and age (F(4, 706)=24.5, p=0.000). No interaction effects were found. The main effects of group and age, using a Bonferroni adjusted alpha level of 0.025, are displayed in table 9 and 10 respectively.

Table 9: Main effects of group

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean score patients</th>
<th>Mean score controls</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total symbols</td>
<td>48.7</td>
<td>69.9</td>
<td>0.000*</td>
</tr>
<tr>
<td>2. # correct symbols</td>
<td>48.3</td>
<td>69.7</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

* p<0.025

An inspection of the mean scores indicated that patients scored worse on both variables than controls. In figure 6 the mean scores and significant differences between patients and controls are displayed.

Figure 6: Mean scores and significant differences between patients and controls**

* significant differences (p<0.05)
** see table 5 Appendix for explanation of variables
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Table 10: Main effects of age

<table>
<thead>
<tr>
<th>Variables</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total symbols</td>
<td>0.000*</td>
</tr>
<tr>
<td>2. # correct symbols</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

* p < 0.025

To identify where the significant differences for age lie, post-hoc ANOVAs were conducted. The results of these ANOVAs are described below.

Patients

In figure 7, mean scores and significant differences between age categories are displayed for patients.

In patients, both dependent variables differ significantly between all age categories; young patients scored best and old patients worst.

Figure 7: Mean scores and significant differences between age categories in patients**

* significant differences (p<0.05)
** see table 5 in Appendix for explanation of variables
Objective cognitive functioning three months after stroke: a comparison of young, middle-aged and elderly patients.

Controls

In figure 8, mean scores and significant differences between age categories are displayed for controls.

In controls, old adults scored significantly worse than middle and young adults, the young and middle adults showed no significant differences.

Figure 8: Mean scores and significant differences between age categories in controls**

* significant differences (p<0.05)
** see table 5 in Appendix for explanation of variables

Covariates

The covariates used in this study were ‘gender’ and ‘level of education’. The results of gender showed no significant effects on the dependent variables. It indicated that the differences in neuropsychological scores did not vary as a function of gender.

However, all three MANCOVAs showed significant effects of ‘level of education’. According to the descriptive statistics, patients (4.7) have a lower level of education in comparison with controls (5.8). Moreover, the level of education decreased by age, with
young people (5.5) having the highest level of education and old people (4.8) the lowest. The level of education of middle-aged adults is in between (5.4). This pattern corresponded to the pattern found on scores of neuropsychological tests, which means there was no interaction between level of education and the independent variables.

**Discussion**

The main aim of the present study was to investigate the effect of age on cognitive functioning after stroke. To examine whether the differences in age in patients after stroke are comparable with the pattern of ‘normal aging’, the results were compared with the results of a control group.

The present study found that stroke patients performed worse on episodic memory and mental speed and attention than healthy controls. However, when analyzing the dependent variables separately, not all results supported the first hypothesis ‘stroke survivors will have a greater impairment in episodic memory, executive functioning and mental speed and attention than healthy control people’.

In the RBMT, there were only four out of 15 variables on which patients scored significantly worse than controls. With these results, we can not conclude that the episodic memory is worse in patients than in controls. This is in contrast to the study of Tatemichi et al. [15], which concluded that memory was one of the cognitive domains in which the most limitations occur in stroke survivors compared with control subjects. The results of the Zoo map test also did not indicate that patients scored worse than controls. So we can not conclude that the executive functioning in patients is worse than in controls. A study of Hurford et al. [18] said that frontal executive function showed strong improvements (30 % impairment at 1 month dropping to under 15% at 3 months), so this could explain why there is no great difference in executive function between patients and controls at 3 months after stroke.
Another explanation could be the use of the Zoo map test for the assessment of executive functioning. This test may be too insensitive to pick up differences in executive functioning between patients and controls.

In the DSCT, patients scored worse than healthy controls on all variables. These results supported the first hypothesis and we can conclude that stroke patients had impaired mental speed and attention in comparison to healthy controls.

The second hypothesis, ‘in both patients and controls, episodic memory, executive functioning and mental speed and attention decrease by age’, is partially supported. For most of the variables, the old adults scored worst and the young adults scored the best, in patients as well as controls.

In the RBMT, not all variables showed significant differences. In the variables which did, a pattern can be seen in which old adults scored worst and young adults best, in patients as well as controls. This trend showed that episodic memory decreased by age. However, because this pattern is seen in only seven of 14 variables, we cannot draw firm conclusions.

Based on the results of the Zoo map test and the DSCT, executive functioning and mental speed and attention decreased with age, in patients and controls.

In general we can conclude that episodic memory, executive functioning and mental speed and attention all decreased as age of the participants increased, which supports the second hypothesis. This is in agreement with the study of Jolles et al. [20], which concluded that older adults are at a disadvantage in tasks which assess concentration, attention and executive functioning. It is also in agreement with the theory of fluid and crystallized intelligence, which said that fluid intelligence peaks in adolescence and begins to decline progressively beginning around age 30 or 40 [21].

The third hypothesis, ‘the effect of age will be greater in patients than in controls (interaction), leading to greater cognitive impairments by aging in patients than in controls’,
is not supported, because in all domains no interaction effects were found. The expectation was that having a stroke as well as an old age would cause more impairments than only having one of those factors. No significant interaction effects were found. By inspecting figure 1 to 8 in the results section, patterns in patients and controls indeed seem the same. However, inspecting all variables separately, a trend (not significant) was detected pointing in the direction of an interaction: In the domain ‘mental speed and attention’, the differences in mean scores between young and old in patients were greater than those differences in the healthy controls. This same pattern was also visible in the variables ‘planning time condition 1’ and ‘total time condition 2’ of the Zoo map test. Noteworthy was that these are all variables covering mental speed. That is why it could be suggested that in people who are both old and have had a stroke, impaired mental speed in the first period (3 months) after stroke is apparent, more so than is the case for healthy elderly subjects. Impaired mental speed and problems with attention could have consequences in the daily life of elderly patients, and may ultimately affect their quality of life. It is important to take this into account in the treatments and interventions patients get in the first months after stroke.

Whereas numerous studies have measured post-stroke cognitive functioning using objective neuropsychological tests, only a few have examined the influence of age. That is why this study can be considered as an important contribution to this area. A strong element of this study was that the instruments chosen are widely accepted and frequently used in daily clinical practice dealing with stroke patients. The battery also contained both traditional neuropsychological and more ecologically valid tests, including the RBMT and a subtest of the BADS. Another strength of the study was that a broad selection of stroke patients was included, not only first-ever strokes or patients discharged home. This increased the generalizability of the results to the stroke population as a whole.
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Despite these strengths however few differences between patients and controls, and no interaction effects emerged. Explanations for this, which can be regarded as points for improvement in future research, are: 1) It could be that patients who participated in this study were patients with a ‘good recovery’ and that is why differences between patients and controls were harder to find [35]. 2) The ecologically valid tests which were used in this study may be too easy or too insensitive. The RBMT is especially useful for the quantification of severe memory problems. For mild memory impairments, this test is too insensitive and too easy [36]. Using another memory test may show greater differences between the different groups. Furthermore, the use of the Zoo map test is not sufficient for measuring executive functioning. To draw conclusions about executive functioning, it would be better to use the whole BADS.

There were a number of other disadvantages in this study that may affect the results. First, the level of education explained a part of the relation between the independent and dependent variables. In this study matching on this variable was not possible, because some groups contained too few participants after matching. The second disadvantage was that there are only 28 stroke patients younger than 50 years. Thereby, the number of participants was not divided equally into the age categories. This may had implications for the conclusions of this study. Moreover, the group of stroke survivors younger than 50 years was too small for generalizing conclusions. That is why this study should be considered a pilot study. Another disadvantage was that only a limited number of tests were used, which may be insufficient for the assessment of cognitive functioning. The last disadvantage was that cognitive functioning was only measured three months after stroke. After three months there is still a possibility of improvement in cognitive functioning. A study of Hofgren et al. (2007) concluded that the recovery of cognition continues during the first year after discharge from hospital [37]. So the
results of the current study were not generalizable to the long-term cognitive functioning. For this, a longitudinal follow-up is needed, something the COMPAS study will address.

Conclusion

Mental speed and attention was impaired in stroke patients in comparison with healthy controls. The impairment in this domain increased with age in patients as well as controls. Moreover, in variables covering mental speed (DSCT and items on the Zoo map test), a pattern could be seen in which a combination of having a stroke and being old worsened the impairments. This means that in old people who have had a stroke impaired mental speed in the first period (3 months) after stroke is apparent.

To draw firm conclusions about episodic memory and executive functioning, more extensive research is needed, with a better distribution of participants in each group, matching on the level of education and the use of more extensive test batteries.

The main message that emerged from this study is that elderly people, irrespective of whether they have had a stroke or not, did more poorly on a variety of cognitive tests than younger participants. For stroke patients however, mental speed and attention was especially affected by age. Slowed down thinking and more problems with attention for elderly stroke patients (compared to their healthy elderly counterparts) could have wide-spread implications for their functioning in daily living and may ultimately affect their quality of life. Future research in this area is very important, so that interventions can take this impairment into account.
Objective cognitive functioning three months after stroke: a comparison of young, middle-aged and elderly patients.

References


Objective cognitive functioning three months after stroke: a comparison of young, middle-aged and elderly patients.


32. van Rijsbergen MWA, Mark RE, de Kort PLM, Sitskoorn MM: Subjective cognitive complaints after stroke: rationale and design of the COMPAS study. 2012


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Appendix

Table 1: Properties of the tests

<table>
<thead>
<tr>
<th>Cognitive domain</th>
<th>Test</th>
<th>Short explanation of the test</th>
<th>Scoring</th>
<th>Psychometric properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Episodic memory</td>
<td>RBMT</td>
<td>Assesses limitations in the ‘everyday memory’. Subtests: remembering an appointment, property, remembering a name and surname, remember delivering a message, remembering a route, orientation, date, reproduction of a story and recognition of images and faces [29].</td>
<td>The individual raw scores of each of the subtests can be converted into a profile score (0,1,2) and a screening score (0,1) [38]. In this study only raw scores were used.</td>
<td>Reliability: insufficient, Validity: insufficient [38].</td>
</tr>
<tr>
<td>Executive functioning</td>
<td>Zoo map test</td>
<td>Subjects are asked to visit six of 12 possible locations in a zoo. They have to adhere to three rules. The test consists of two conditions. In the first condition little external structure is provided, and the second condition is a situation in which a concrete, imposed strategy has to be followed.</td>
<td>The score is based on the successful implementation of the plan and the time needed to complete the tasks. Penalties are imposed for rule breaks [30].</td>
<td>Inter-rater reliability: good, Test-retest reliability: good, Validity: insufficient [38, 39].</td>
</tr>
<tr>
<td>Mental speed and attention</td>
<td>DSCT</td>
<td>Consists of nine digit-symbol pairs followed by a list of only digits. Subjects have to write down the correct symbols belonging to the given digit during 120 seconds.</td>
<td>The score is the total number of correct symbols written down [31].</td>
<td>Reliability: good (0,84) [31].</td>
</tr>
</tbody>
</table>
Table 3: Mean scores and standard deviations of the RBMT

<table>
<thead>
<tr>
<th>Domain</th>
<th>Test variables (maximum score)</th>
<th>Patients</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Young (N=28)</td>
<td>Middle (N=71)</td>
</tr>
<tr>
<td>Épisodic memory</td>
<td>Rivermead Behavioural Memory Test</td>
<td>1. Story direct recall (21)</td>
<td>8.4 (2.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Recognition of images (10)</td>
<td>9.7 (0.9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Route direct recall (5)</td>
<td>4.8 (0.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Delivering a message direct recall (3)</td>
<td>2.9 (0.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Recognition of faces (5)</td>
<td>4.9 (0.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Orientation (9)</td>
<td>8.9 (0.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. Date (1)</td>
<td>0.9 (0.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8. Remembering an appointment (4)</td>
<td>1.7 (0.7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9. Story delayed recall (21)</td>
<td>7.6 (2.8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10. Route delayed recall (5)</td>
<td>4.7 (0.7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11. Delivering a message delayed recall (3)</td>
<td>2.7 (0.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12. Remembering a name (2)</td>
<td>1.8 (0.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13. Remembering a surname (2)</td>
<td>1.6 (0.8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14. Property (4)</td>
<td>3.4 (0.7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15. Total profile score (24)</td>
<td>20.9 (3.5)</td>
</tr>
</tbody>
</table>
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Table 4: Mean scores and standard deviations of the Zoo map test

<table>
<thead>
<tr>
<th>Domain</th>
<th>Test Variables (maximum score)</th>
<th>Patients</th>
<th></th>
<th>Controls</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Young (N=26)</td>
<td>Middle (N=69)</td>
<td>Old (N=106)</td>
<td>Total (N=201)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>x (sd)</td>
<td>x (sd)</td>
<td>x (sd)</td>
<td>x (sd)</td>
</tr>
<tr>
<td>Executive functioning</td>
<td>Zoo-map test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Planning time condition 1*</td>
<td>54.4 (38.9)</td>
<td>67.4 (69.5)</td>
<td>71.8 (110.4)</td>
<td>68.0 (90.9)</td>
<td>63.9 (64.4)</td>
</tr>
<tr>
<td>2. Total time condition 1*</td>
<td>144.1 (55.2)</td>
<td>173.9 (82.0)</td>
<td>211.6 (119.1)</td>
<td>189.9 (103.6)</td>
<td>112.7 (67.7)</td>
</tr>
<tr>
<td>3. Score condition 1 (8)</td>
<td>3.9 (4.0)</td>
<td>3.6 (3.8)</td>
<td>1.9 (3.7)</td>
<td>2.7 (3.8)</td>
<td>6.0 (2.7)</td>
</tr>
<tr>
<td>4. Planning time condition 2*</td>
<td>12.0 (17.0)</td>
<td>12.9 (18.6)</td>
<td>11.1 (18.5)</td>
<td>11.9 (18.3)</td>
<td>10.6 (15.4)</td>
</tr>
<tr>
<td>5. Total time condition 2*</td>
<td>67.8 (31.4)</td>
<td>73.0 (33.9)</td>
<td>102.5 (58.0)</td>
<td>87.9 (50.2)</td>
<td>49.5 (24.1)</td>
</tr>
<tr>
<td>6. Score condition 2 (8)</td>
<td>8.0 (0.0)</td>
<td>7.6 (1.4)</td>
<td>6.9 (2.3)</td>
<td>7.3 (1.9)</td>
<td>8.0 (0.2)</td>
</tr>
<tr>
<td>7. Total score (condition 1 + condition 2) (16)</td>
<td>11.9 (4.0)</td>
<td>11.2 (4.1)</td>
<td>8.7 (4.7)</td>
<td>10.0 (4.6)</td>
<td>14.0 (2.8)</td>
</tr>
</tbody>
</table>

* no maximum

Table 5: Mean scores and standard deviations of the DSCT

<table>
<thead>
<tr>
<th>Domain</th>
<th>Test Variables (maximum score)</th>
<th>Patients</th>
<th></th>
<th>Controls</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Young (N=28)</td>
<td>Middle (N=71)</td>
<td>Old (N=110)</td>
<td>Total (N=209)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>x (sd)</td>
<td>x (sd)</td>
<td>x (sd)</td>
<td>x (sd)</td>
</tr>
<tr>
<td>Mental speed and attention</td>
<td>Digit Symbol-Coding test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Total symbols (133)</td>
<td>63.4 (16.9)</td>
<td>55.1 (16.1)</td>
<td>40.9 (14.5)</td>
<td>48.7 (17.5)</td>
<td>79.4 (14.7)</td>
</tr>
<tr>
<td>2. # correct symbols (133)</td>
<td>63.3 (16.2)</td>
<td>54.7 (15.8)</td>
<td>40.4 (14.5)</td>
<td>48.3 (17.5)</td>
<td>79.2 (14.7)</td>
</tr>
</tbody>
</table>
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Table 11: Classification of the Dutch Educational System by Verhage (1964) [26].

<table>
<thead>
<tr>
<th>The levels of education as stated by Verhage:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Below elementary school/ elementary school not finished</td>
</tr>
<tr>
<td>2. Elementary school (finished)</td>
</tr>
<tr>
<td>3. Elementary school finished and further education for less than 2 years</td>
</tr>
<tr>
<td>4. Less than MULO/MAVO-level, for example LTS, LEAO, LHNO</td>
</tr>
<tr>
<td>5. MULO/MAVO/MEAO diploma</td>
</tr>
<tr>
<td>6. HAVO/VWO/HEAO/HBS/HBO diploma</td>
</tr>
<tr>
<td>7. University diploma</td>
</tr>
</tbody>
</table>

Low/average level of education

High level of education